An Economic Evaluation of Agricultural Management Systems in the Patagonian Grasslands: An Observation of Wool and the Link Between Profitability and Conservation

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(signature)

Abstract:

Historically, the region of Patagonia was built on sheep ranching and the production of wool. Since the early 19th century, farmers have grazed these temperate grasslands, which has led to the rapid expansion and growth of the meat and textile industry. This sudden growth has had numerous negative ecological impacts on this very fragile ecosystem and broader socio-economic effects. Grazing peaked in 1952 at 22 million sheep, and since then has steadily declined to approximately 8.5 million sheep (Borrelli & Cibils, 2005). Concentrated conservation efforts aim to address this crisis and better manage the land in hopes of recovery.

My research focuses on the farmer's perspective and the inherent switching costs for shifting to a sustainable grazing program in order to regenerate the land. This study analyzes several financial decision models over a five-year investment period within three ecological areas in Patagonia: the Central District, the Subandean Grasslands, and the Humid Magellan Steppe. Within each ecological zone, I account for three agricultural management scenarios: traditional grazing, basic planning, and holistic management. In addition, this analysis takes into consideration the process of the wool value chain and influence that the textile industry has on the fate of the Patagonian Grasslands.

By understanding the financial risks in each of the modal farms, the objective is to provide accurate financial information to the farmer for the assumed switching costs and the expected timing in which the land is projected to have recovered. The majority of the research is derived from an Argentine non-profit, Ovis XXI, which monitors 55 ranches throughout Patagonia. Because many of these ranches face dire economic conditions, switching to a sustainable grazing program could be their last venture option. Thus, the expected results of investment are crucial and the value of switching to a sustainable grazing program can only be captured if the basic fiscal needs are met. My objective is to understand within each ecological zone the best agricultural management plan that optimizes both ecological and financial capital.

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Preface

As the author of this Master's Project (MP), my association to this analysis is only as a graduate student in the Fuqua School of Business and the Nicholas School of the Environment at Duke University. Given that my Master's Project is a client-based analysis, information and collaboration has come from Patagonia Incorporated, Ovis XXI, and The Nature Conservancy. In addition, I spent several weeks, monitoring the grasslands throughout Argentine Patagonia and was able to garner first-hand information and data on the project. Overall my research focuses on the creation of nine financial decision models over a five-year time period covering three ecological areas: the Central District (MSC), the Subandean Grasslands (PSA), and the Humid Magellan Steppe (EMH). Within each ecological zone, I accounted for three agricultural management scenarios, which are: traditional grazing, basic planning, and holistic management. Furthermore, I conducted additional sensitivity analysis to better understand the farmer's switching costs for each agricultural plan, risk, and overall the best decision for each ecological zone. My objective for this project is to analyze and support the best financial scenarios for the ranching communities of the Patagonian Grasslands; and increase the optimal biological capital for these recovering ecological areas by modeling the predicted outcomes.

Chapter 1. Introduction:

The vast and delicate ecosystem of the Patagonian Grasslands covers 400 million acres of temperate grasslands and supports a dynamic biological and cultural community. The history of Patagonia is founded on sheep ranching and the production of wool. Patagonia was one of the last regions in South America to be colonized by European settlement. After the Argentine government gained power in the 1880's, the economic vitality from wool and meat production was already established (Aagesen, 2000). Through the rapid development of the ranching industry over a short period of time, the grasslands of Patagonia became severely degraded and in many instances can no longer support the utilization of livestock.

During the summer of 2012, I interned with Patagonia, Inc. and was introduced to their Grassland Regeneration and Sustainability Standard (GRASS). This standard is a collaboration between Patagonia Incorporated, The Nature Conservancy, and Ovis XXI. In their respective order, their commitment to the project is: building for-profit demand, offering third-party quality assurance, and being a non-profit on the ground facilitating ranch relationships, providing grassland evaluations, and maintaining data to ensure sustainable grazing programs. GRASS is a certification system that encourages sustainable grazing throughout the Patagonian Grasslands and creates a value chain that aims at maintaining and regenerating these fragile ecosystems through the consistent demand of wool sourced in a sustainable manner.

Upon completion of the internship, Patagonia, Inc. proposed further investigation of the GRASS project as a viable MP. In addition, I found the project was to be an opportunity to gain knowledge on sustainable sourcing, supply chain management, and the application of raw material traceability programs. In the winter of 2014, I received a research grant [1] and traveled throughout the grasslands of Patagonia performing grassland evaluations, gathering data, and understanding the necessary financial capital and switching costs for sustainable grazing programs. In addition, I analyzed the supplemental biological benefits (e.g. increased soil stability) from changing to a sustainable grazing despite the large upfront costs.

Throughout my research, I found several key findings that give insight to the potential decision-making posed at farmers in these regions. First, in all of the ecological areas and for all of the agricultural management plans, holistic management was the better financial and biological option.[2] The enhancement of holistic management was especially apparent in the Central District, the options for continuous grazing (traditional management) or reducing the sheep stocking rate by 30% (basic planning), created negative profit margins in the financial decision models. In fact, the only positive profit margin for the Central District was through applying holistic management despite the upfront costs that may inherently deter the farmer from switching to a sustainable grazing program. A large reasoning for holistic management being the best option in the Central District is due to the arid landscape, which hinders biological resilience for recovery. Therefore, the duration of time for the land to recover in a dry area is much longer than in the humid regions of Patagonia. In addition, it has been shown that mild grazing patterns applied with the constraints of the ecological carrying capacity could actually increase the rangeland health and assist in the unification of the grassland patch structure.

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[1] This funding was through the Nicholas School Internship Fund and the Placement Intern Fund and was
[2] This methodology will be further described in, "Chapter 4: Methods".

Second, holistic management is much more profitable in the Subandean Grasslands than the Central District, and furthermore the profit margins skyrocket in the Humid Magellan Steppe in comparison to the other three ecological zones. This research shows that the opportunity for profit and recovery of the grasslands is much larger in the wet regions in comparison to the dry regions, and this is indicative to the resilience of the land. However, in each ecological zone and as mentioned prior, holistic management is still the best financial and biological option to maximize resource recovery and financial output.

The intentional goal of this research is to show the value of the land and the market value of investing in sustainable grazing programs despite the upfront costs. This is a tremendous undertaking given the vast expanse of grasslands that sprawl over Patagonia and the additional challenges of Argentina's economy resulting in the devaluation of currency and volatile inflation rates. Therefore, switching costs for other land management systems, despite the long-term beneficial outputs, can derail the farmer's short-term operations. Despite the desire from the consumer to buy sustainably sourced products and the desire from industry to provide them the initial switch starts with the farmer. This analysis creates probable outcomes that evaluate the necessary capital and costs in order to make these shifts feasible.

Objectives

For my Masters Project, I will be working on an individual client-based project with the outdoor apparel company, Patagonia, Inc. Research and information for the project has also been conducted in conjunction with Ovis XXI and The Nature Conservancy. This study focuses on the sheep ranching industry, given that Patagonia, Inc. sources wool from the ranches. The main objective of the project is to complete a series of financial decision models examining the differences between the financial and environmental inputs in three agricultural management scenarios: traditional grazing, basic planning, and holistic management. In order to analyze a conclusive sample, these three agricultural management scenarios will be observed in three ecological zones: the Central District (MSC), the Subandean Grasslands (PSA), and the Humid Magellan Steppe (EMH). The purpose of choosing these three ecological zones is in order to assess a worst-case scenario (MSC), to a mid-range scenario (PSA), to a best-case scenario (EMH). Given that there are 15 distinct ecological zones covering 55 farms, the rationale was to have a sample size that covered majority of the Ovis XXI farm data without including all of the data points.

Through the application of holistic management, grasslands in the Patagonian region have been documented to be more productive over the long-term than conventional agricultural practices. Therefore, through increased land productivity and regeneration of the grasslands, there has also been a commensurable link in the increased quality of the wool from sheep within these sustainably harvested regions. By observing the financial data from each grassland management scenario, my research will analyze the differences between each agricultural plan, the opportunities to build biological capital, and the optimal financial framework for the ranching communities in each ecological zone.

GRASS provides an opportunity to shift the purchasing power in the wool supply chain at the raw material level and build industry creditability through traceability programs monitored on the ground level. In addition, it also offers a unique opportunity for sourcing to be regenerative, instead of detrimental to the ecosystem. Although, this concept is in the nascent stages, my research intends to bolster the feasibility of sustainable supply chains at the raw material level. One of Patagonia's Inc. goals is to provide a global standard for further sustainable wool purchasing and gain more wool accounts from other large industry players. By building these decision models, we gain further insight on the most frequent probable outcomes of implementing sustainable grazing programs.

Hypothesis

For my MP, I hypothesize that holistic management will be the most economically feasible option and also increase the rangeland health index (RHI) by the greatest degree for each ecological zone. In the instance of the arid ecological zones, such as the Central District (MSC), the importance of switching away from the traditional grazing method in order to maintain profitability will be the most important. The dry regions have shown to be the most degraded and the slowest to regenerate, while the humid regions have shown to be the most resilient and quickest to recover. Therefore, the importance of implementing sustainable grazing programs in order to maintain the land's carrying capacity and a profitable operation will start to lessen as the ecological zone mimics a mid-range scenario (Subandean Grasslands, PSA), to a best-case scenario (Humid Magellan Steppe, EMH). My research focuses on the switching costs for farmers to transition to holistic management or basic planning from traditional grazing programs. These changes entail incremental costs and when these farms are marginally profitable, an additional investment can seem like a tremendous burden. In order to support the investment needed to improve the rangeland health of the Patagonian Grasslands, I hypothesize:

If the fiscal ability to switch to holistic management or basic planning can be shown through a five-year financial model, then the willingness to switch will increase if the profit margins are positive and the improvement of the land can be exemplified.

I will use a series of financial decision models and observe three ecological zones using three different agricultural management programs. By outlining the needed capital infrastructure, additional costs, additional benefits, and impact on the land; I will be able to identify if the modal farm will be profitable or if the farmer faces the risk of bankruptcy. [3]The depth of this analysis will be further explained in, "Chapter 4. Methods".

Chapter 2. Conversation Planning Overview:

This chapter is dedicated to providing information on the historical lineage of Patagonia's sheep ranches, the natural characteristics of the land, and the land management plans that are most commonly used throughout the Patagonian Grasslands.

The Historical & Environmental Landscape of the Patagonian Grasslands

History of Sheep Ranching in Patagonia & Rangeland Management

Throughout the settlement and colonization of South America, Patagonia was one of the last regions to be developed (Aagesen, 2000). By the mid 1800's, the primary economic expansion was based on sheep ranching and in 1910 the area supported approximately 12

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[3] Note here that modal farm, which refers to the frequency of data for each farm scenario, and the term ranch are used interchangeably throughout this analysis.

million sheep. This general population peaked at 22 million in 1952, and has steadily declined to approximately 8.5 million into the 21st century (Borrelli & Cibils, 2005). This waning regression of sheep population has largely believed to be an influence of overgrazing the land and the correlated negative effect that it has on the environmental health of the rangeland.

The climate in Patagonia is unforgiving and varies throughout the regions from dry to wet, cold to hot, windy to humid, and despite the variation in climate the elements are harsh nonetheless. These severe elements make it difficult to focus on many other agricultural commodities besides livestock. Although other commodities have been attempted, such as garlic, none of them were as predominant as sheep ranching to the identity of the grasslands (Borrelli, 2014). This identity has molded within the inherent framework of Patagonia and thus, the health and vitality of the land is also a direct contribution to the economic livelihood of its people.

Many initiatives have looked to address the situation of overgrazing prompting desertification in the Patagonian grasslands; but only in the last two decades have the initiatives been able to be monitored, properly assessed, and able to regenerate the landscape. More specifically, the accessibility of computer technology broadened the monitoring process and allowed for satellite imagery to track carrying capacity and the degradation of the land over time (Borrelli & Cibils, 2005). In addition, the practice of Geographical Information System (GIS) in accordance with satellite mapping allowed for other data inputs to be systematically monitored, such as soil quality, erosion, biodiversity, and other biological factors.

More recently, Decision Support Systems (DSS) are a new tool being introduced to the rangeland industry. One of the application of DSS is Conservation Action Planning (CAP), which identifies conservation goals and strategies and allows the farmers to practice adaptive management. By creating yearly goals and tracking them through an organized analytical system, owners of the ranch with the assistance of a management team are able to adapt their conservation plan in order to meet optimal solutions each year. In addition, the information can be modeled and predict probable situations that allow for heightened accuracy in land planning and mitigating overall risk.

Traditionally, these sustainable grazing initiatives often suggest reducing stocking rates in order for the land to recover (Borrelli, 2014). Generally, reducing stocking rates is not economically viable option for the farmer. In addition, most of the land is privately owned or divided into large private estates in Patagonia and thus the collaboration of conservation with the ranching industry is imperative for regeneration (GRASS 2.0, 2012). Sheep ranching is one of the strongest inhibitors for desertification within this region and poorly managed lands can degrade the landscape past the point of production. The threat of diminishing grasslands due to desertification must be addressed through conservation initiatives that involve the private sector but also reflect the economic livelihood of the farmer.

Although this geographic region is struggling to stabilize its rangeland health, it is still one of the formative and largest sheep ranching communities in the world. Research has shown that sustainable grazing programs can assist in recovering these degraded lands. The application of controlled grazing has the opportunity to greatly benefit two thirds of the earth's uninhabited land by reversing desertification, improving soil quality, increasing crop cover, and boosting biodiversity (Coughlin, 2013). In addition, this vast expanse has the potential to salvage the economic vitality that historically sculpted this region of the world.

Characteristics of the Patagonian Grasslands

Argentina is the 8th largest country in the world and the entire region of Patagonia withholds 400 million acres of temperate grasslands. This expanse ranges from 39° to 55° south and is comprised of southern Argentina and Chile. Within this immense region, the climate varies from arid to semi-arid with the mean temperature fluctuating from 15.9°C in the North to 5.4° C in the South (Borrelli & Cibils, 2005). The large disparities in Patagonia's climate are due to the effects of temperature upon the latitudinal gradient and the dispersion of west-to-east precipitation (Bertiller & Bisigato, 1998). My research focuses on Argentine Patagonia, which comprises of approximately 173 million acres and includes the provinces Neuquén, Río Negro, Chubut, Santa Cruz, and Tierra del Fuego. [4]

The grasslands are known for being a fragile ecosystem and the resilience of land varies with each ecological region. Plant communities in Patagonia obtain a low plant cover ranging from 10-60% and are dominated by two main plant species, perennial grasses and shrubs (Bertiller & Bisigato, 1998). Traditionally, free range ranching is the method most commonly used and therefore the sustenance of the sheep population is directly reliant on the abundance of perennial grasses (e.g. *S. speciosa)* and shrubs (e.g. *C. hystrix*).[5] The changes in grass species cover can be a direct reflection on the preferential diet of the

[4] (Bertiller & Bisigato, 1996). The amount of acres stated in this scholarly journal was 700 km^2. However, I convert that to 172,973,767 acres and approximated to 173 million acres in the body of paper.

sheep and these eating behaviors can negatively influence the reproduction cycle of the perennial grasses and shrubs.

In Patagonia, there is only one native ungulate herbivore called the Guanaco that grazes the land and interferes with the perennial grasses that the sheep consume. Therefore prior to the development of sheep ranching the land endured only light grazing pressure (Borrelli & Cibils, 2005). Since the late 19th century, Patagonia has undergone large modification throughout the grasslands mainly due to the rapid expansion of wool and meat production. Given that most of Patagonia's grasslands have been negatively affected by domestic livestock grazing for over a century, there are serious issues regarding soil erosion and degradation, water instability, and lack of fauna and flora biodiversity. This is largely due to the lack of agricultural planning to forecast the appropriate carrying capacity and the necessary time for the land to recover between grazing cycles.

In the arid regions of Patagonia, grasses grow in a patchwork structure alternating between groups of grasses and bare soil. In the semi-arid region, the structures are more connected due to the increase in precipitation and dominated by woody shrubs. There are 378 vascular plants in the semi-arid and arid region of Patagonia and this region includes the provinces of Neuquén, Río Negro, and Chubut. In southern Argentine Patagonia, the area is comprised of the Santa Cruz and Tierra del Fuego provinces and is characterized by tussock, short grasses, and shrubs (P.L. Peri et al., 2013). Research has shown in these regions that pressures from light grazing can increase the overall plant cover and the heterogeneity of the grassland patch structure (Bertiller & Bisigato, 196).

The rangelands of Patagonia account for two-thirds of the spatial structure, and within each rangeland area there is a variation in dominant plant species, rainfall, climate, and other biological factors (see Table 1). The landscape throughout Patagonia was heavily modified by the sheep ranching industry in the early 20th century. This modification was prior to environmental monitoring and therefore, it is extremely difficult to know the composition of the terrestrial area prior to Pre-European settlement (Aagesen, 2000).

Table 1:

Table 1. Rangeland types of Argentina

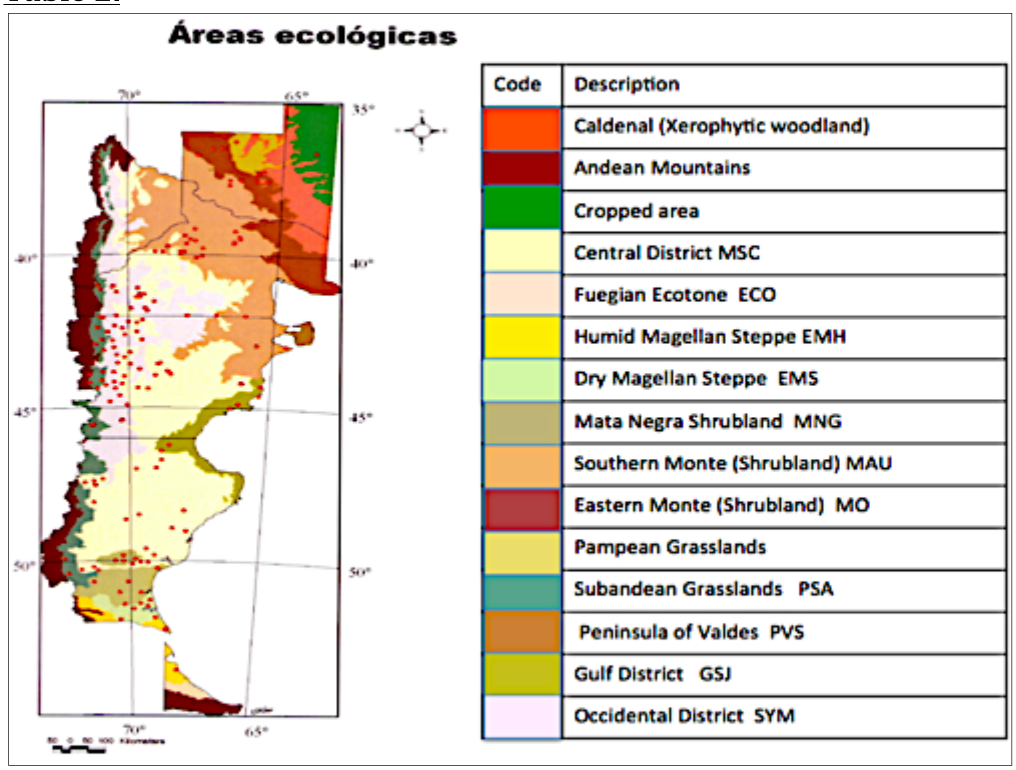
	Rangeland type	Area (ha)	Mean rainfall (mm/year)	Plant communities (physiognomy)	Dominant plant species
Arid and semiarid grasslands, shrublands, and woodlands*	Patagonia (cold deserts and semi-deserts)	60 million	300	Shrub steppes	*Mulinum spinosum, Adesmia campestris, Junellia tridens, Stipa humilis, Stipa speciosa, Poa ligularis*
				Grass steppes	*Festuca pallescens, Festuca gracillima, Poa dusenii, Beberis heterophylla*
				Meadows (valley bottoms)	*Festuca pallescens, Juncus balticus, Holcus lanatus, Poa pratensis*
	Monte (hot and cold deserts and semi-deserts)	46 million	80–300	Shrub steppes	*Larrea divaricata, Prosopis alpataco, Lycium chilense, Trichloris crinita, Eragrostis argentina, Bouteloua aristidoides*
	Caldenal (semiarid woodlands)	2.3 million†	350–500	Woodlands	*Prosopis caldenia, Condalia microphylla, Prosopis alpataco, Prosopis flexuosa, Stipa tenuis, Stipa gynerioides*
	Western (dry) Chaco (semiarid woodlands and savannas)	65 million	320–800	Mid- to low forests and savannas	*Schinopsis lorentii, Aspidosperma quebracho-blanco, Prosopis alba, Prosopis nigra, Leptochloa virgata, Paspalum inaequivalva*
	Puna (cold deserts and semi-deserts)	9 million	200	Shrub steppes	*Junellia* sp., *Chuquiraga* sp., *Nardophyllum* sp., *Adesmia* sp., *Mulinum* sp., *Stipa caespitose, Stipa leptosthchya*
Subtropical humid forests and savannas*	Eastern (wet) Chaco (subhumid forests and savannas)‡	25 million	800	Forests and savannas	*Schinopsis lorentzii, Aspidosperma quebracho blanco, Schinopsis balansae, Prosopis alba, Prosopis nigra, Elionurus muticus, Sorghastrum agrostoides, Panicum prionites, Paspalum intermedium, Paspalum almum, Paspalum urvillei, Spartina argentinensis, Juncus capillaceus, Juncus macrocephallus*
	Espinal (forests, woodlands, savannas)	3 million	1,000–1,200	Forests and savannas	*Prosopis alba* and *Prosopis nigra, Prosopis algarrobilla, Butia yatay, Setaria geniculata, Bothriochloa laguroides, Paspalum urbillei, Paspalum dilatatum*
Temperate humid grasslands*	Pampas (temperate grasslands and grass steppes)	50 million	700–900	Grasslands	*Paspalum dilatatum, Lolium multiflorum, Stipa neesiana* (uplands); *Bothriochloa laguroides, Stipa papposa* (plains); *Leersia hexandra, Glyceria multiflora* (humid lowlands); *Distichlis spicata* (alkaline lowlands); *Paspalum quadrifarium* (uplands, plains, and humid lowlands)
Sub-Antarctic forests*	Nothofagus forests (temperate semideciduous forests)	2 million	≥1,000	Forests and savannas	*Nothofagus pumilio, Nothofagus antartica, Berberis* spp., *Holcus lanatus*

*See Further Readings online at http://dx.doi.org/10.2111/RANGELANDS-D-10-00016.s1 for supporting references.
†Originally, 7.5 million.
‡Includes subtropical grasslands and wetlands.

Source: Anderson et al., 2011

Within the area of Patagonia, there are 15 distinct ecological areas. In Table 2, the ecological areas monitored by Ovis XXI [6] are outlined in the thematic map. Each red dot on the map represents a farm that Ovis XXI monitors and are the data points used to create modal farms in my research. In order to create a conclusive data set of all the ecological zones, I used data from the ecological zones with the most populous data points. In addition, I wanted to the models to not only capture frequency but to be representative of best to worst case scenarios in terms of economic and biological conditions. Therefore, the objective was that this population sample would be indicative of the entire region. The methodology behind choosing the ecological zones and the construction of the financial decision models will be discussed in greater detail in Chapter 4.

<u>Table 2.</u>



Source: GRASS 2.0, 2012

[6] The extent to which Ovis XXI is involved will be explained in greater detail in, "Chapter 3. Proposed Industry Solution".

Types of Land Management Plans

This section will cover the different types of land management plans that are most commonly used throughout the rangelands of Patagonia and are also used as the scenario proxies for the analysis data.

Overview of Farm Size and Scope

According to, "Grasslands of the World", there are three main sizes for sheep ranching farms: 1) large commercial farms (6000+ heads), which are the generally derived from first settlements on the most productive lands; 2) medium to small farms (6000-1000 heads), characterized by being located in the more arid regions and struggle financially due to the volatility of the wool market; and 3) subsistence farms (<1000 heads), known for being passed down through aboriginal families and allow the livestock to graze without paddocks.[7] The distribution of the number of sheep is shown within each district and exemplifies the disparity gap between subsistence and small-to-medium farms to big commercial farms (see Table 3). Overall, most of the ranch owners in the Patagonian Grasslands struggle with poverty, and generally own less than 10% of their sheep (Borrelli & Cibils, 2005).

[7] Borrelli & Cibils, 2005

Table 3:

Province	Criterion	Subsistence farms	Small to medium units	Big companies
Chubut	By no. of farms:	52%	43%	5%
	By no. of sheep:	8%	61%	31%
Neuquén	By no. of farms:	89%	9%	2%
	By no. of sheep:	20%	44%	36%
Río Negro	By no. of farms:	69%	30%	1%
	By no. of sheep	20%	64%	16%
Santa Cruz	By no. of farms:	16%	65%	6%
	By no. of sheep:	2%	49%	49%
Tierra del Fuego	By no. of farms:	-	37%	63%
	By no. of sheep:	-	10%	90%
Total Argentinian	By no. of farms:	54%	40%	6%
Patagonia	By no. of sheep:	8%	54%	38%

SOURCE: Data from Casas, 1999.

Throughout the rangelands of Patagonia, the sufficient fiscal variability is contingent upon issues of environmental degradation, climate, and the best adaptive land management plan. Within each ecological zone, the main differentiating factors are the amount of rainfall and the severity of the temperature. Therefore, the appropriate carrying capacity to maintain sustainable production is a relative measure of the climate factors and the resilience of the land. In my analysis, theses factors were some of the main drivers in determining the best land management plan.

Traditional Management

For the analytical models, the application of traditional management is the practice of continuous grazing. This methodology allows for no application of controlled grazing patterns or adjustments to enhance the biological inputs. Throughout Patagonia, the sheep ranching community has allowed the sheep to roam the land without fenced paddocks. However, given the degradation of the land and the limitation of the forage availability for the sheep, continuous grazing has shown to incessantly impede the land.

In each modal farm scenario, many of the factors were fixed such as the sheep population or the number of hectares. These fixed parameters mimic the most frequent framework for farm dynamics in each ecological zone. However, with the sustainable grazing plans (described below), factors such as carrying capacity or other incremental costs, varied given the adjustment in the land management plan.[8] In this analysis, the traditional plan maintains the modal farm's original inputs, considers no biological or fiscal enhancements to the land, and assesses the farm's financial state over a five-year production cycle.

Basic Planning

One of the sustainable land management plans is basic planning, which focuses on lowering the stocking rate to a percentage that is appropriate for the land to recover to its suitable carrying capacity. On average, when applying basic planning the stocking rates are lowered between 20 to 30 percent (Borrelli, 2014). One example of adjusting stocking rates for increased productivity was within the Chaco region of Argentina. This region's goal was to match stocking rates with volatile forage accessibility (Anderson et al., 2011). Through adjusted stocking rates and rest periods, the ranchland in the Chaco district has the potential to increase productivity if this adjusted period is followed by strong rainfall. A heavy rainfall will result in increased forage availability, and thus allow the farmer to increase his overall carrying capacity and production over the long run. However, this is a large risk since by decreasing the stocking rate, there is also a decrease in the immediate productivity and inherently, the profitability. The conditional probability of improvement

[8] The variation and assumption in each land management plan will be described in greater depth in, "Chapter 4. Methods".

is largely affected by rainfall and climate conditions, particularly in the arid regions, where drought and lack of water are very common.

For more than half a century, flexible and moderate stocking rates have been used to mitigate environmental degradation throughout the ranchlands of Patagonia. Moderate to light grazing pressure has shown to improve the rangeland health and individual animal production (GRASS 2.0, 2012). However, as shown in the example above, decreasing stocking rates can also lessen immediate productivity. If the particular farm is in an economically difficult situation, decreased productivity can result in bankruptcy. To better understand the financial decision in the perspective of the farmer, this analysis focused on the applied stocking rates reflective of each scenarios carrying capacity and the necessary biological inputs. Given Patagonia's climatic variability, agricultural plans must be prescriptive to the type of environmental conditions that are pertinent to the adaptive management plan. The extent at which each stocking rate was applied for each ecological zone and land management plan will be described in greater detail in, "Chapter 4". Methods".

Holistic Management

The practice of holistic management was originally developed by Allan Savory and has shown to improve rangeland conditions and regenerate grasslands. The concept of holistic management was introduced in the 1960's and the impetus for this new management system was derived from the ineffectiveness of mainstream rangeland science. Savory believed that the result of environmental degradation, the loss of biodiversity, and the lack of farm productivity was all a reaction to the loss of natural grazers in the area (Coughlin, 2013). The nascent inception began with a belief that by mimicking nature, grasslands have the potential to regenerate. Given that the lands were created with native ungulate grazers; instinctually domestic grazers should not be as detrimental to the environment if managed properly.

Instead of viewing livestock as a negative factor, holistic management implies that domestic ungulate grazers, such as sheep, have the ability to provide positive ecosystem services such as nutrient cycling and crop tillage (Benyus, 1997). Holistic management applies rotational grazing programs, yet also considers the aspect that each grassland is a unique biological ecosystem. The goal of holistic management is to have prescriptive programs that cater to each farm's inputs and through third-party quality assurance programs, such as GRASS, there is opportunity to build demand for wool sourced in a sustainable manner. However as described above in regards to Patagonia's heterogeneous climate, rotational grazing patterns in which holistic management suggests, are not always the best option for some ecological zones. Therefore, most conservation initiatives such as GRASS, suggest that the ranches apply adaptive management plans that are pertinent to the each region's necessary inputs for recovery. In particular, double sampling is recommended by applying the Santa Cruz Method and Animal Day Squares (GRASS 2.0, 2012). [9]

[9] The Santa Cruz Method and Animal Day Square methodology will be described in greater detail in, "Chapter 4. Methods".

Chapter 3. Proposed Industry Solution:

In this chapter, we will discuss the triad relationship between Patagonia Inc., Ovis XXI, and The Nature Conservancy and their intent to promote sustainable grazing programs and conserve grasslands. In their respective order, this is a unique and influential collaboration between a private company known for sustainable products and supply chain, a world-renowned science-based conservation non-profit, and on-the-ground specialists monitoring the grasslands and implementing adaptive management plans (GRASS 2.0, 2012).

Through this partnership, they have set a common goal of certifying 4.0 million hectares under a sustainable grazing program by June 2015 (GRASS 2.0, 2012). This is essentially 1% of the total area of the Patagonian grasslands. As of March 2014, these active players have currently certified 1.27 million hectares. Although there is a large gap between the current situation and the proposed goal, the program will continuously adapt to further preserve the region and strengthen the implementation. In order to gain an understanding on the rationale of these three proposed groups and their willingness to strive for conserving this ecosystem, the chapter below is dedicated to explaining collaboration of these key players.

Industry Background & Proposed Objectives

Conservationists have identified grasslands as an under-protected ecosystem type worldwide, and the Patagonian grasslands are an example at risk of losing biodiversity and an important carbon sink. Wool producers in the region see the degradation of grasslands and resulting desertification as threatening to their business model. The land is almost exclusively held by private ranchers or divided into ranch estates and so achieving grassland conservation through large government reserves is not an option. Therefore, conservationists must work with the ranching industry to achieve their goals in this region. In order to incentivize ranchers to adopt sustainable grazing methods, a market demand must be created for wool (and meat) produced in this way. A progressive buyer must be identified as a first-adopter to drive the demand. And in order to support the claims of sustainable production, a standard and a traceable certification system must be established.

A defined science-based protocol for sustainable grazing and an associated certification process has been developed, called Grassland Regeneration and Sustainability Standard (GRASS).

Initial Concept & Certification Structure

With the implementation of GRASS, there are three main goals in order to protect the land, the community, and the biological capital. The goals set by the GRASS 2.0 Handbook are:

1. "Protection and restoration of Patagonia's grasslands and its unique and fragile environments.
2. Maintenance of viable populations of key native wildlife, including puma, zorro Colorado, rhea, and guanaco.
3. Providing stable markets for high-quality grassland products, including wool and meat. These markets will, to the greatest degree possible given changing market conditions, provide pricing that sustains the economic vitality of qualifying farms

and reflects reasonable costs of production associated with producing the highest quality wool and meat and protecting and restoring native grasslands and wildlife”.[10]

To reach the three main goals of the GRASS certification system, farmers must apply adaptive management plans that are indicative to each ecological zone and necessary inputs for recovery. Each plot of land has a unique set of biological factors in order to help the land recover, and GRASS does not want to limit entry to the program by assuming one large solution. Below are the six steps that a farmer will entail as their land is being assessed: [11]

1. Evaluation
2. Problem Identification
3. Objectives and goals definition
4. Farm Planning
5. Execution (Management Change)
6. Monitoring

Once these initial steps are taken into place to reach optimal sustainability goals, structure, and monitoring plan; the farmer will work towards qualifying for the GRASS certification. In order for the farmers to participate in the GRASS certification and have access the additional benefits, they must partake in an official land auditing process. The GRASS 2.0 Handbook shows the necessary steps in order to manage adaptive management plans and the process in which farmers can qualify for the GRASS certification (see Table

[10] Goals are directly sourced from the GRASS 2.0 Handbook, 2012.
[11] These adaptive management steps are directly sourced from the GRASS 2.0 Handbook, 2012.

4). Once the farm has passed the required land audits, then the farmers have access to the sustainable branding program in which they are able to access to premium retailers at a higher price and inherently make a larger profit.[12]

Table 4:

Step	Description	Activities	Responsible
1	Evaluation of available information	• Verify compliance of Adaptive Management. See documents. • Complete Form. AA1	Auditor
2	Define Sampling Plan of the Farm	• Define paddock transect according to maps and existing roads. • Define Station number and representativeness	Auditor
3	Evaluation of Biological Indicators (Rangeland Health)	▪ Farm transects and field assessment in several stations- FormAA2	Auditor
4	Calculate Score and Class	▪ Add indicators by station and average farm score	Auditor
5	Prepare Auditor Report	▪ Preparation and presentation of Audit Report. Form. AA3	Auditor
6	Input Farm Audit Database	▪ Input Audit Results in Audit Database and Farm Folder. ▪ Check for pending issues and recommendations.	Ovis XXI Central Node

Table 11. Work sequence for Environmental Audits

Source: GRASS 2.0 Handbook, 2012

Patagonia, Inc.

Patagonia Inc. supports this project by purchasing wool that is certified by the GRASS standard. Being the first company to nominate this certified fiber in their products, Patagonia, Inc. is supporting the regeneration of the land by providing demand for wool from ranches certified to GRASS and achieving positive Rangeland Health Indicators. Additionally, Patagonia, Inc. is marketing their wool products by promoting the environmental benefits of sustainable grazing in the supply chain. This educates consumers

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[12] The process in which the farms make a larger profit by incorporating these sustainable grazing plans will be explained in more detail in, "Chapter 4. Methods".

and other brands to the environmental benefits and marketing potential of wool produced from sustainable grazing practices. By increasing demand for GRASS certified wool, the goal is to entice other ranchers to switch to sustainable grazing programs in order to have access to premium brands and higher prices.[13] In addition, another hope is to inspire industry of the potential of preserving one of the largest grasslands in the world through the GRASS certification structure and to recognize the influence of large retailer's purchasing power. In 2013, all of Patagonia, Inc.'s merino base layers and socks were sourced from the GRASS certified-wool program and tracked through internal traceability databases to ensure the implementation of sustainable grazing programs.

Given that Patagonia, Inc. is my client for my MP, they were also participatory in the framing of the analysis and the expected results. Throughout this research, my work was evaluated by Jill Dumain (Director of Environmental Strategy), Todd Copeland, (Environmental Product Specialist), and Elissa Loughman, (Environmental Analyst). Their goal is to reduce the environmental impact of their supply chain, develop a consistent reliable source of high quality wool fiber, and develop closer relationships with the raw material suppliers. Patagonia, Inc. also believes this is an opportunity to improve their brand equity and potentially shift the global purchasing power towards sustainably produced fiber by setting a new wool standard and certification system.

The results of sustainable grazing programs have shown to have regenerative results in three to five years (Borrelli, 2014). However, quantifying the increase in the rangeland health index and overall productivity can be difficult to quantify from a fiscal perspective. My MP is not intended to support any biased results, but rather evaluate if

[13] As of March 2014, two additional premium brand accounts have began sourcing from GRASS, which are Stella McCartney and Benetton.

holistic management is better option in terms of enhancing the biological and financial capital in the perspective of the farmer. In addition, this research hopes to encapsulate the hopeful prospect of regenerating the grasslands by running a series of probable outcomes. By understanding the probability in the perspective of the farmer, we also have a better understanding of the feasibility of industry to implement this program at the ground level.

Ovis XXI

Ovis XXI is a certified B-Corporation that works with a network of farmers, academics, and agricultural technicians to establish an evaluation system that promotes healthy grasslands throughout Patagonia. Throughout this cohesion of the GRASS certification structure, Ovis XXI is the local non-profit that is on-the-ground participating in the data collection, monitoring programs, and applying the adaptive management programs. [14] They are also responsible for keeping an updated record of the accredited farms that are within compliance of the GRASS certification and are the local counterpart that understands the necessary biological, cultural, and fiscal factors in order for the farmer to switch into a sustainable grazing program.

Given that the farmers are the nexus of this entire program, receiving their buy-in is one of the crucial factors in order to improve the land. According to the GRASS 2.0 Handbook, the main roles of accredited farmers are: [15]

- Stewardship of their grassland (property),
- GRASS compliance,
- Follow recommended measures from Land Audits,

[14] At this location, I gathered majority of my data points for the modal farms from Ovis XXI's database.
[15] These roles are directly sourced from the GRASS 2.0 Handbook, 2012.

- To install a continual learning process about conservation and sustainable production issues. Pioneer a cultural change (current and future generations), and
- Participate as desired in Conservation Action Planning (CAP) processes pertaining to his/her region.

Through these major roles, the farmer dictates the vitality of the land. One of the key functional roles that Ovis XXI provides is the ability to foster relationships that promote sustainable grazing programs with the intent of long-term profitability and rangeland health. The upfront costs of switching into these new agricultural management plans can be perceived as a large financial burden to the farmer. In order to assist with the fiscal burden, Ovis XXI has partnered with The Nature Conservancy to manage a ecosystem services program that provides small grants in order to assist certain low-income farmers with the initial costs. In addition, Ovis XXI's success stories have engaged many community members, where neighboring farms can literally watch the benefits to the land and understand how they outweigh the costs. This worth-of-mouth scenario has been proven to be very successful in this community, where the lands are so degraded. Therefore, any implementation system that improves the current situation is readily adopted.

In the Patagonian region, Ovis XXI is the leading expert in applying sustainable grazing programs and has some of the longest standing relationships with farmers. They are viewed as a credible and trustworthy source and their value is especially intrinsic to the region in comparison to the other industry players. Therefore, their network and evaluation services are crucial to the project's success in accurately monitoring the data, expanding the amount of farms participating in the program, and ensuring the traceability programs are successfully being executed.

The Nature Conservancy Argentina

Established in 1951, The Nature Conservancy (TNC) is a leading conservation non-profit agency with offices all over the world. In regards to this project, The Nature Conservancy has an office in Bariloche, Argentina and that office branch is responsible for third-party quality assurance for the project's data reporting and ensuring traceability for the branding services for Patagonia, Inc. In particular, TNC works closely with the same ranches that Ovis XXI monitors and supports the project by offering their scientific expertise and supplementary auditing. Incurring this supplemental assurance and auditing in the program helps to build creditability and the potential to be expanded to a global certification standard that can be applied to the wool industry at large.

Another benefit of having TNC involved in the project is that they offer assistance in leading Conservation Action Planning events. This supplementary provision assists Ovis XXI's through additional services and coordination for the adaptive management plans. Given that this project covers such a large region, the extra coordination helps strengthen the project's ability for success. Because of their non-profit status, TNC is instrumental in collecting donations and distributing payments for ecosystem services to some of the farmers involved in the project. This fund allows a group of selected farmers to have access to grants in order to incur the upfront costs of switching to these sustainable grazing programs.

Wool Industry

This section will be discussing the main drivers in the wool industry and aim to give a better understanding of the estimated wool price, volatility of the wool market, and overall market drivers.

Wool Pricing Statistics

My wool pricing statistics examined the Australian Wool Exchange over seven harvests and set the model ranging from 19.5 to 28 microns. One of the leading indicators for pricing is microns, since they are a direct measurement of quality. In general, the lower the micron, the finer the wool, then the higher the price. My wool pricing statistics revealed that on average the Argentine farmer makes 27% less than the Australian farmer. Implications for this gap is most likely due to the strong market power driven by the fact that Australia produces much larger volumes in comparison to Argentina.

In order to close the disparity gap between the Australian and Argentine spot price for wool, the prices are calculated using the following equations:

- The price in terms of $US per a kg of greasy wool: [16]
    - Greasy wool= Australian clean wool price*(1-GAP percentage)*Yield
- Pricing in Basic Planning and Holistic Management:
    - The change in wool price= % of wool sold with branding*the change in price of exported wool

[16] Wool Statistics tab found in Appendix 1.

One of the main goals for Ovis XXI is to bridge the gap between the Australian and Argentine prices for wool within the Argentine market. A farmer that switches to sustainable grazing programs approved by GRASS is offered a higher price for the wool given access to premium industry accounts. This higher price is indicative of the higher prices set at retail stage and this increased profitability margin also makes it back to the farmer in order to reflect the social and environmental costs. In addition, Ovis XXI's service intended to close the pricing gaps by building sustainable grazing programs, increasing brand equity through the raw material sourcing story, and mitigating risk through long-term pricing contracts.

Australian Wool Exchange & the Influence on Global Wool Prices

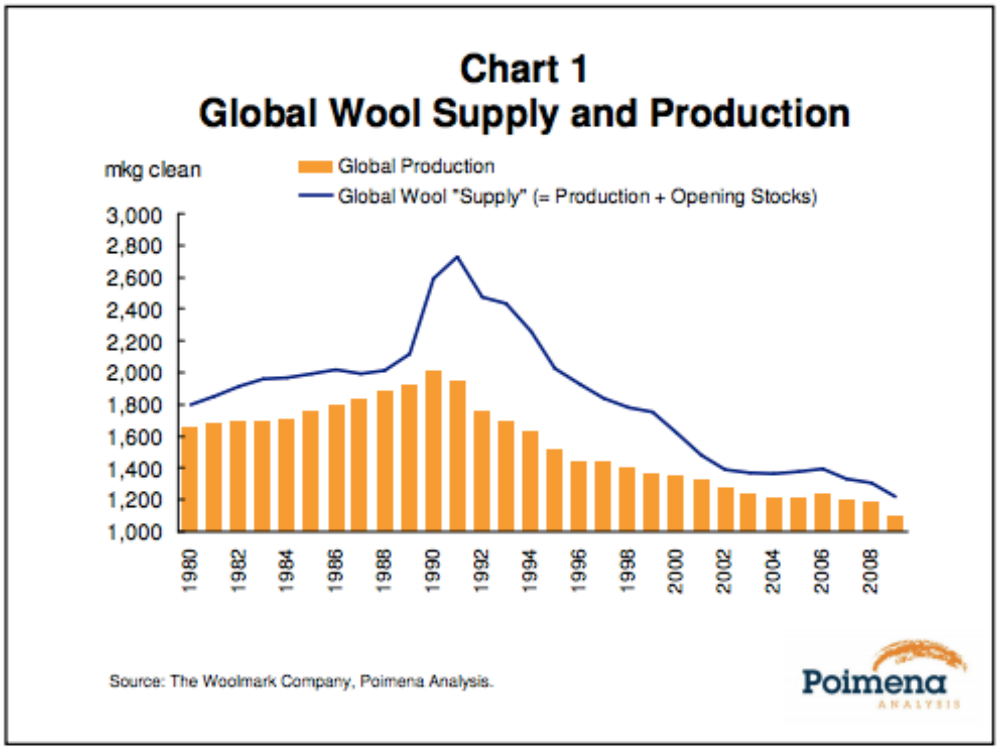
The Australian Wool Exchange (AWEX) is compilation of wool indicators that assess the appropriate pricing structure for wool. The Micron Price Guides (MPG's) are set categorical data determining the wool class and these prices are calculated on a daily basis and distributed to subscribed wool industry players. [17] Given that Australia is one of the top producers of wool, the AWEX framework is one of the main guides in setting the global price and this reference is used in a majority of wool journals describing their pricing structure. In general, AWEX has a large global influence and is a standard in the Argentine wool market for assessing price implications.

Many other variables can affect the price of wool including severe weather conditions (e.g. drought), inflation, the devaluation of currency, increase in competitive textiles, and other market factors. In addition, from 1991 the global wool market has been

[17] AWEX, 2014

declining as a whole (see Table 5). Production has fallen from a majority of wool producing countries, including Australia and Argentina, and the wool market is suffering largely due to the demand and competitive pricing of cotton and synthetics. As a reaction to the wool commodity crisis, many major exporters have reduced their stocking rates in order to stabilize quantity of production in regards to the economic return.

Table 5:



Although the wool market is struggling on a global scale, there is always opportunity within times of crisis. With these major set backs in production, there is a chance to re-assess the ranching parameters and limitations. In regards to this project, the GRASS certification allows for the ranching communities to consider new principles in applying agricultural procedures and embrace the opportunity of "getting ahead of the curve" through new land management practices. Some of this innovation is seen in sustainable grazing programs and relationships with premium brands that are spearheading raw material traceability programs. Since wool is one of the most natural fibers in textile production, the story for supporting the land, animals, and people that maintain this production has incredible socio-economic and environmental potential.

Argentinean Economy and Issues with Inflation

At the end of the 19th century, Argentina was viewed as a potential economic superpower; given its access to natural resources, it's abundant size, and the ability to foster and grow international trade (Lewis, 2001). As time passed, the internal struggle between political powers and economic chaos fluctuated through many decades of hardship and Argentina began to lose their status in the power race. These setbacks have greatly affected Argentina's future and as they rebuild their country's economy there are many important factors to consider in order to stabilize their inflation rates and the devaluation of currency.

As a combination of economic hardship and environmental degradation to the land, sheep ranching has began to lose traction as the main monetary driver, and is respectively runner up to oil and gas production, fisheries, and most recently tourism.[18] In addition, during the last quarter of the 20th century, wool production has accounted for less than five percent of the regional Gross Domestic Product (GDP).[19] Improvement of the land could increase the forage availability and therefore, increase production allowing for sheep ranching being a main economic catalyst in this area once again. However, fluctuating wool

[18] Coronato et al., 2011
[19] Ibid.

prices and volatile inflation rates makes improvements of the land difficult to incur the upfront costs.

Sustainable grazing plans are able to recover the land and possibly regenerate. This is one of the first times in the textile industry that a supply chain has been able to improve the conditions to the point of regeneration. There is an innovative opportunity to shift the way that we operate in terms of industrial standards. Farmers are able to access long-term contracts with brand accounts that endure fixed pricing structures for a set amount of time, this allows the farmer to mitigate risk and essentially buy "futures" that help them hedge risk within the volatility of the wool market.

Specialized Pricing Structure for Patagonia, Inc.

In order to encourage wool and meat farmer's to switch to sustainable grazing programs, a large incentive is the ability access the demand from premium brand accounts. However, creating long-term accounts in order to ensure higher prices for the farmers can cause detrimental economic effects for both the farmer and industry. In the case of the farmer, if the wool prices are high for that year and continue to rise, then the long-term price can result in a large loss. For industry, if wool prices are low and the contractual price is high, then the company can lose a lot of money over the course of a season. With wool prices being very unstable, predicting these types of adjustments can be extremely difficult.

In Table 6, the value chain diagram shows a simple supply chain and the common amount of transactions that the wool industry will need to sustain before it reaches distribution. Throughout these transactions, dictating each exchange can be even more difficult than forecasting the overall price. In order to mitigate risk, Patagonia Incorporated has been working alongside Ovis XXI and accounting for the learning experiences from each season. One main takeaway was to limit the amount of exchanges that the price is negotiated upon to alleviate inflation. In order to put this into practice, Patagonia, Inc. now allows Ovis XXI to negotiate the price directly with the spinner.

Another main takeaway was the number and duration of the contracts being set at year. There is speculation that longer contracts may have caused the prices to have more time to fluctuate, leading to more opportunities for a loss rather than a reaction in order to provide a gain. With this learning, Patagonia, Inc. and Ovis XXI decided to shorten the duration of the contracts in order to be more flexible to the ebbs and flows of the wool market. This permitted these groups to build volume and demand by ensuring long-term demand within short-term contracts. Lastly, in order to ensure that the price of wool will help cover the incremental costs to the farmer, Ovis XXI suggests that the advantage will remain if the contract price is noticeably superior to the spot price.

Table 6: Where does Fiber go?

Source: Copeland, 2013

In a proposal written by Ovis XXI for the fall 2012 to spring 2013 wool pricing structure, the main goals were listed in order to help ensure both parties are satisfied:

1. Cover the incremental cost incurred by the farmer
2. Have a clear advantage compared with the traditional farmer (market signal)
3. Reach a fair profit level

Ovis XXI believes that if the first objective is met, then the second objectives inherently are accomplished. They are also strong proponents of price being one of the main drivers factoring whether farmers will switch into sustainable grazing programs or not. At the moment, switching from a system that has been applied for over a century, despite how degraded the land, is still a large shift in the traditional livelihood practices. Ovis XXI believes that in order to cover the incremental costs of the farmer, wool prices should be at least 20% higher for sustainable farms than the traditional farmer applying continuous grazing (Borrelli, 2011).

Ovis XXI further explains in their pricing proposals that defining these fair prices is still yet hard to define and defining those higher prices can't be simply determined by the leading spot price. For example, when spot prices are low both traditional and sustainable farmers are losing money. However, even when spot prices are slightly higher, traditional farmers can make a small profit on their total capital, approximately 0.66%, while sustainable farmers are just breaking even at 0.01%. Therefore, spot prices must be very high for sustainable farmers to make a profit and they are at a disadvantage in some scenarios due to the incremental costs.

Ovis XXI believes that in order to create fair pricing contracts for sustainable wool, there must be a clear definition in sustainable profit. In their projected pricing proposal for fall 2012 to spring 2013, they assessed that two main objectives would help maintain sustainable profit. The first being a fixed term deposit at 1.76% per annum and secondly, the option for farmers to have the option to buy and rent 5-6% of the land that they manage. In order for farmers to be incentivized to switch to a sustainable grazing program, profits must be at least 1.5% over the traditional farmer. [20]

Within the pricing proposal for Patagonia, Inc., a modal farm was assessed managing 2400 heads at and 20-micron wool average. In this proposal, Borrelli shows that a 1.5% profit is needed in order to minimize the gap between the Australian and Argentine spot price and incentivize the farmer to take on the incremental costs of sustainable grazing (see Table 7). When the wool is set at an average of 19-micron, the profit increases to 2.8% (see Table 8). The decrease in the micron is an indicator of the increase in the quality of the wool. However, very strict breeding programs and diets have the ability to reach these low micron and fine wool level, and therefore the increases profit is due to the amount of additional management that is needed in order to reach this criteria. [21]

[20] Ideally, this would be 3-5% to maintain long-term commitments from farmers.

[21] Ovis XXI also offers breeding programs that offer this change in the wool, however they assess the change from 20 to 19 microns takes approximately 5-10 years (Borelli, 2011).

Table 7: % Profit of Merino producers in Patagonia (Average 20 Micron)

Prices	Farmer price USD/Clean	% of Aussie Spot	% Profit Traditional	% Profit Sustainable
Arg Spot Price	11,54	80%	0,66%	0,01%
Break even point	12,95	91%	0,66%	0,66%
Sustainable Prices	14,3	100%	0,66%	1,24%
	14,9	**104%**	**0,66%**	**1,50%**
	16,05	112%	0,66%	2%
	18,36	128%	0,66%	3%

Table 8: % Profit of Merino producers in Patagonia (Average 19 Micron)

Prices	Farmer price USD/Clean	% of Aussie Spot	% Profit Traditional	% Profit Sustainable
Arg Spot Price	$14,60	85%	2,30%	1,49%
Break even point	$16,77	98%	2,30%	2,30%
Sustainable Prices	$17,09	100%	2,30%	2,43%
	$17,95	**105%**	**2,30%**	**2,81%**
	$20,70	121%	2,30%	4%

Source: Borrelli, 2011

Although these projects are multi-faceted and take many components in order to create a tipping point, the possibilities for creating long-term social and environmental benefits are numerous. Over time and through continuous collaborative discourse, the appropriate pricing and ordering methodology will continue to be refined that mitigates risk, improves the social and environmental conditions of Patagonia, and aims to maximize profit.

Chapter 4. Methods: Data Collection, Modeling, & Calculation:

In this chapter, I will discuss the methods that I used in order to determine the probable outcomes for these three agricultural management plans within the three selected ecological zones. A large majority of this data was compiled during my research trip to Argentina over January and February of 2014. During my trip, I worked closely with Pablo Borelli, who is the head manager of Ovis XXI and a leading expert in the Argentine wool industry.[22] The data collected in this study is a combination of interdisciplinary literature resources, modal data from Ovis XXI's farm accounts, and first-hand research conducted during grassland evaluations in Argentina.

Methods Overview

In this section, I will describe the process of creating a series of financial decision models to better understand the optimal agricultural management plan that is in the best financial and biological interest for the farmer. First, I created a list of parameters that served as the necessary data inputs for each land management plan in each ecological zone. Second, by adjusting the parameters given the constraints in each scenario, I created the steady-state income analysis that forecasted the final economic analysis. Next, I complied the main output factors for each scenario that determines the final operational result in order to understand the fiscal gains/losses.[23] This final compilation allowed me to understand the probable outcome of these decision scenarios and the inherent switching costs to a sustainable grazing program within each ecological zone.

[22] Note that he is also the author of majority of the publications that I used in this MP, and this is due to the fact that his publications dominate this literary space.

[23] These main output factors are: operational result (EBITDA), return on equity, and the profit margin.

In framing these financial models, I set them to take into account the time value of money and projected the financial analysis to be set in the fifth year. Under the supervision of experts in the field, this was the projected to be the average amount of time the land needs to respond from the application of sustainable grazing programs.[24] Most frequently, within the first two years there is no noticeable recovery from the implementation of adaptive management and/or change to the land. On the third year, the farmer usually breaks even in terms of cost and land recovery. The fourth year represents a gradual decline and/or incline to the final investment result in the fifth year, in which the results of these agricultural land management plans can be observed for their final financial gain and/or loss.

During the creation of these models, Ovis XXI and I agreed that the fifth year was the average determining length of time for understanding if the farmer should make a long-term investment in a sustainable grazing program. In addition, given the frequency data and from Ovis XXI's experience, five years is the average amount of time needed for the farmer to receive any sort of financial payback and receive any benefits from the recovery of the land (e.g. increased forage availability). Consequently, an impediment on implementing these programs from a land management viewpoint is the long duration of time that it takes to endure these programs before any noticeable change. One objective of the this analysis, is that the creation of these probable scenarios allows the farmer to have a better understanding of the most frequent outcomes and therefore have a baseline framework in order to gauge their investment.

The analysis section draws upon three main contributing data sources:

[24] A list of assumptions is found in the, "Appendices" section.

1. Ovis XXI Data: Scientific surveys and grassland evaluation data from the Central Node Database from the Ovis XXI headquarters. These farms have traditional grazing, basic planning, and holistic management agricultural plans and have been monitored from two to 25 years. Overall, I took the most frequent data sets for each ecological zone and created a modal farm. Data was directly sourced from the farms that have been surveyed in Patagonia by the Ovis XXI team.
2. Instituto Nacional de Tecnología Agropecuria (INTA): This organization is one of the main centers of information in Argentina in regards to Agriculture, Livestock, and Fisheries. Developed in 1956, INTA is the one of the main supporting establishments for the majority of the scholarly articles that I used to support this research. Within my analysis, I also applied the grassland evaluation methodology called the Santa Cruz Method, which was created by INTA. This method assesses the forage availability by evaluating the amount of shortgrasses to herbs, and other biological indicators (i.e. biodiversity) to create a utility index (Olivia et al., 2006).
3. Literature Review: A compilation of literary sources to ensure the validity of the grassland, animal husbandry, and economic assumptions that applied to the model.

Description of the Three Ecological Zones: Central District, Subandean Grasslands, and the Humid Magellan Steppe

When first creating these financial decision models, I worked with Ovis XXI to distinguish the three necessary ecological zones that would be representative of the entire population sample. Currently, Ovis XXI monitors 55 farms within 15 distinct ecological zones over the vast expanse of 400 million hectares temperate grasslands throughout

Patagonia.[25] In order for the data to be representative of the all the monitoring stations without building a copious amount of models, we categorized the data for climate, degradation, and economic conditions.

In regards to climate, our models are representative for dry and wet climates and a mid-range scenario in order to include climatic variability along the north south transect of the Andes. Since the land takes the longest to recover in the arid regions, we wanted to account for that extended duration of time and the also account for the wet regions where the land is much more resistant. The recovery of the land is a large indicator for the success of the project and therefore, there are clear recovery gaps between each ecological zones. The Rangeland Health Index (RHI), which is a numerical score for the condition of the land, is incorporated into each ecological zone, in order to assess the baseline of environmental degradation for each ecological scenario. In conjunction to the climate scenarios, we wanted the analysis to exemplify the worst economic situation, best economic situation, and a mid-range scenario to cover a myriad of economic scenarios. Coincidentally, the rangeland health in these scenarios was also directly indicative to the economic situation.[26]

Therefore, our model is a good overview of the entire population sample by assuming these three ecological zones:

Three Ecological Scenarios:[27]

- Central District (MSC): the worst-case scenario due to the fact that the land is arid, the economic conditions are poor, and the land is the least resilient. This is a result

[25] Out of all the farms that Ovis XXI monitors, 53 out of 55 are in Argentina. Therefore, this analysis focuses on Argentina as the primary indicator for economy and climate and is closely comparable to Chile.

[26] For example, in the arid environment it also has poor economic conditions and the humid environments have better economic conditions.

[27] See table 2.

of the land being the most degraded in this area and thus, having a longer and more difficult time regenerating.

- Subandean Grasslands (PSA): the mid-range scenario that runs a north south transect along the Andes. This is the mid-range scenario because it covers a large area of Patagonia's climates, economic conditions and land resilience. Thus, being the best ecological zone for an overall average.
- Humid Magellan Steppe (EMH): the best-case scenario given the humid and wet climate, good economic conditions, and positive land resilience. This land is located near Tierra Del Fuego, and the Argentine government is known for providing high wages and tax breaks for doing business and working in this region. This is due to the fact the weather this far south is particularly harsh and in addition to the long durations with little sunlight in the winter months. Incentive programs such as this have stimulated businesses to put headquarters in this region and create a more burgeoning population in a once low population area.

Within those three ecological zones, we had to make a list of assumptions in order to normalize the data. We took the average of all of the farms that Ovis XXI monitors and found that the modal farm size is approximately 23,000 ha. Therefore, we set a fixed acreage of 23,000 ha for each modal farm with each ecological zone. [28] In order to account for the variation in land management plans and their end fiscal result, we needed to account for a farmer that applied: a traditional grazing, basic planning, or holistic management. By applying these land management scenarios, our goal was to understand

[28] All parameters are explained in great detail below.

the best financial decision for the farmer in the fifth year given each ecological zone. In addition, this analysis would help us gain insight for the main drivers between each pastoral plan. For example, which climatic scenario predicts the best payback potential and which probable outcomes give insight to areas suffering from environmental degradation.

Overview of the Three Land Management Systems: Traditional Grazing, Basic Planning, & Holistic Management

In order to understand the inherent switching costs between each ecological scenario, we needed to account for the different data inputs and outputs between each land management plan. In addition, this information is fundamental in order to understand the differences in the financial investment from the perspective of the farmer and the amount of time that is needed in order to recover the land for each payback period.

In our model, the land management scenarios are defined as follows:[29]

- **<u>Traditional:</u>** The farmer does absolutely nothing to enhance their land. The modal farm applies continuous grazing and within the five years there is a small incremental change to the stocking rate. The stocking rate is slightly higher than the carrying capacity within each ecological zone and this is derived from Ovis XXI frequency data.
- **<u>Basic Planning:</u>** In order to improve the land, the farmer chooses to destock his flock by our assumed stocking rate for each ecological zone. This decrease in the number of sheep per a hectare allows for less grazing, and this lack of impediment generally leads to an increase in forage availability. In this scenario, the rate of recovery of the land is indicative of the biological resilience of the land. In addition, this application of land

[29] All land management scenarios are described in greater detail in the, "Data Framework and Scoping Parameters" section.

management can be difficult to gain farmer buy in, due to the fact that a decrease in the stocking rates also leads to a decrease in short-term productivity. With these sustainable grazing plans generally taking five years to show any noticeable change, this investment window can be the difference to a ranch being in business or not.

- **Holistic Management (HM):** In order to improve the land, the farmer decides to apply the techniques of holistic management (HM). This includes increasing the stocking rates given the frequency data for each ecological zone, and performing intensive livestock rotational grazing within smaller plots of land for shorter periods of time. By having the sheep in smaller areas for shorter periods of time, they are able to till and aerate the soil, urinate and defecate in order to provide nutrient cycling, and then be moved to another plot of land in order to repeat the process. HM applies the mimics the process of natural grazers, but through controlled grazing patterns so that the previous managed lands have the appropriate amount of time in order to benefit and recover. In Ovis XXI's experience, HM has shown to improve forage availability, land productivity, individual animal performance, and result in a noticeable change in the land the first couple of years of being applied.[30] However, there are incremental costs in order to apply HM. Our models assesses the most frequent outputs in the fifth year given the upfront costs and the time needed in order for the land to recover.

Data Collection and Scoping the Parameters

During my time in collecting data in Argentina, Ovis XXI and I created a total of nine financial decision models in order to analyze the three land management plans within

[30] The amount of time in order to recover is dependent on the degradation of the farm, the climate, and is prescriptive to each ranching scenario. However, on average Ovis XXI has noticed some change in the land from HM within the first two years.

three separate ecological zones. Each model has a prescriptive set of parameters and the data used garnered through literary research, articles published by INTA, and data collected through over 20 years of grassland evaluations by Ovis XXI. In regards to the grassland methodology, we applied the Santa Cruz method, "that evaluates forage biomass by direct cuts of shortgrasses and herbs, and utilization degree using residue height of key species of short grasses" (Borrelli & Olivia, 2001). Each model adjusts for a prescriptive set of parameters that are pertinent to the respective land management plan and ecological scenario.

Each model is adjusted for each land management plan within the respective ecological zone and covers the following data analytics: [31]

- Parameters pertinent to each decision scenario
- Income
- Labor Costs
- Overall costs (fixed, variable, and incremental)
- Capital
- Economic Analysis and Major Output Factors
- Wool Pricing Statistics

In this section, the pertinent variables that adjust for each model are described below:

- <u>Parameters:</u> [32]

In the models, the parameters section is a list of all the most frequent input factors for each modal farm given Ovis XXI grassland evaluation data. These parameters map out the following data input sections:

[31] Outlines of the models are found in the Appendix section, 3-6.

[32] A detailed version of the parameter inputs is described in the glossary section at the end of the paper. In addition, overviews of the models will be listed in Appendix 3-6.

- Population dynamics: This segment covers the overall animal husbandry and the allotted amount of sheep and type for each modal farm. In addition, it includes necessary constraints such as carrying capacity, stocking rate, etc.
- Sales: Given the appropriate population animal dynamics used for each scenario, the sales of those animals are also indicative of the frequency data. Sales will be dependent on the carrying capacity, and the type of climate that allows for certain breeds or types of sheep to be more profitable in some areas over others.
- Wool Indicators: These factors include criteria such as the micron levels that are most commonly found, the yield of wool output, the weight of greasy wool in comparison to clean wool, etc.
- Prices: This data input targets the types of prices found for both wool and meat, which varies across each zone and the type of sheep being sold (e.g. lambs vs. hoggets). More information on the estimated wool price will be described in the, "Wool Pricing Statistics" section below.
- Purchases: This portion of the parameters focuses on the amount of sheep that must be bought in order to maintain the animal population dynamics. This includes both the ewes and rams and is measured in $US dollars per a head.
- Environmental Indicators: This section focuses on the rangeland health and is measured by a variety of biological factors such as wind erosion, soil stability, and biodiversity. All of this data is gathered during Ovis XXI grassland evaluations through a range of surveys and is complied into one numerical index ranging from -100 to 100. More information on this topic will be covered in the, "Environmental Inputs" section.

- Income: This tab includes information on the annual income of wool and meat sales given each modal farm and is an imperative input for the final economic analysis.
- Labor Costs: This segment shows the differences amount of staff fully and temporarily employed in each decision scenario. In addition, the differences in the amount of wages paid on average are also accounted for. Labor is considered a fixed cost, yet has its own tab within the model due to the fact that there are different applied labor taxes as opposed to overall taxes, monetary funds, and other extraneous factors that influence the final output.
- Overall Costs: In this segment, an overview of fixed, variable, and incremental costs are applied to each decision model. Fixed costs include inputs such as supplies, energy needed for the farm, and maintenance of assets. Variable costs can be factors like the price of shearing, veterinary fees, and the amount of necessary fodder for each region. Lastly, incremental is one of the most fundamental cost factors because it measures the necessary investment in the perspective of the farmer in order to switch from a traditional grazing program to a sustainable grazing program. These specific incremental costs are services that include wool classing programs, grassland evaluations, and holistic management education. In the final output analysis, these incremental costs are the pertinent investment factors that are necessary in order to be approved by the GRASS certification system and for the farmers to have access to premium brands.
- Economic Analysis and Major Output Factors: After all of these major data input tabs are complied for the final economic analysis tab that is a summary sheet for all the major output factors. These output factors take into account the main drivers in

whether or not the farmer will be profitable or not in each modal farm. In, "Chapter 5: Analysis", the results of the major output factors will be discussed.

Incremental Costs for Conservation Planning

The remainder of, "Chapter 4. Methods", will cover a summary of the structure, assumptions, and calculations used to create the financial decision models in this analysis. These assumptions and notes are built off the historical monitoring data for each ecological zone, Ovis XXI's grass evaluation database, INTA research frameworks, and extensive literature reviews. In addition, one of my main resources for garnering this data and building the appropriate model outline was derived from the accumulation of over 20 years of professional experience that the Founder of Ovis XXI, Pablo Borrelli, has working with wool and meat farms throughout Patagonia. In this analysis, we assumed a modal farm and the scope of each decision scenario is dependent upon the most frequent monitoring data for each ecological zone and land management plan. In particular, this segment provides an overview of the incremental costs and calculations of switching to a sustainable grazing program in the perspective of the farmer.

Assumptions

Overall, there are two main factors that define the model's structure. One of the first influential factors is the ecological zone that dictates a number of important climatic inputs such as the average rainfall, percentage of plant cover, elevation, and soil degradation. Given the strength of their influence, these biological responses can pose major constraints and limitations on important outputs affecting yield, quality, and efficiency. The second major factor directing the model's structure is the size of the farm, and this factor greatly influences the productivity, income, and cost.

The models in this analysis aim to mimic sustainable grazing scenarios, therefore I applied the most frequent data (i.e. mode) to create nine modal farm scenarios in three distinct ecological zones. Each farm scenario varies on the pertinent parameters. For example, one of the sustainable grazing strategies is basic planning and on average decreases their stocking rate by 30% in order to improve the land. However, they generally keep more ewes in this land management technique in order to increase the flock later. The frequency of these types of alterations are streamlined and accounted for in the models.

In general, the restocking rates and productivity is very much based on the ecological zone, the level of environmental degradation, and the resilience of the land. In addition, we assumed that all the farms within the simulation were fixed at prepartum shearing, which refers to the shearing pregnant ewes prior to lambing season. The effect of shearing the pregnant ewes has shown to increase lambing and weaning rates.[33] Therefore shearing prior to lambing is shown to be a cost effective method in the ranching community, and is common practice in Patagonia. Our models will reflect these types of weaning and lambing rates found in Ovis XXI's frequency data.

For the selling of hoggets on the land, we will assume that the sale is set at US $0 for all of the animal population. Hoggets are the name of the first shearing phase for sheep older than seven months, and it is known for being the period where the quality of the wool is the finest in their life span. The fact that sale is set at US $0 is a result of the farmer breaking even on costs and the most likely scenario is that they do not have a surplus of

[33] Cloete et al., 1994.

hoggets to sell. According to Ovis XXI, this is the most likely scenario with hogget sales and indicative of what truly happens on the land.

In addition carrying capacity is based on the forage availability of the land. We have assumed that each ecological zone can carry a certain amount of animal dynamics based on the frequency data. In holistic management, the farmer will not surpass carrying capacity. Thus, for these scenarios, we assumed that the carrying capacity and stocking rate are the same in order to be conservative in our estimates since the land that is being monitored by Ovis XXI is past the point of degradation. Historically, holistic management increases the stocking rate given that it is an application of intensive farming for shorter periods of time. In addition, in these scenarios we will assume that the weight of the animals for sustainable grazing programs (i.e. basic planning & holistic management) will increase in comparison to traditional grazing programs. This is due to the fact that on average the application of these programs increases forage availability and Ovis XXI's other services (e.g. breeding programs) will also help with flock improvement. On the other hand, we will assume no changes in the traditional grazing scenario to improve the land and will remain the same over the simulated five-year investment period. The only change will be small incremental increases to the stocking rate in order to mimic a larger flock, which is the most frequent scenario in traditional grazing.

In order to streamline the data and analyze the feasibility of the data across a vast data set, each section of the model has a set of core assumptions. Across each model scenario, we assumed the following assumptions while sculpting the modal farm's inputs for overall land and animal dynamics parameters. In addition, the model's data inputs and outputs are a product of Ovis XXI's frequency data gathered from on-the-ground grassland evaluations:[34]

- Total Area: took the average amount of hectares in the entire project (e.g. the total 55 farms monitored by the local non-profit, Ovis XXI), which is projected to be 23,000 ha for each farm. This size was fixed for each scenario (unit: ha).
    - The fixed area is 23,234.96 ha. This is if you take the farm list and add the total number of hectares and divide by the number of farms=average size of the modal[35] farm that is monitored by Ovis XXI (I rounded to 23,000 ha).
- Carrying capacity: in this scenario, it is defined as the maximum number of total sheep that can warrant sustainable conditions per a hectare of land set over a five-year period (unit: head/ha).
- Stocking rate: defined as the number of animals per a unit of land over a certain time period (Redfearn & Bidwell, 2014). In our analysis, we are looking at the amount of sheep (heads) per a hectare set over a five-year period (unit: head/ha). For example, in a basic planning scenario, the stocking rate can change from 5-20% over five years (dependent on the ecological zone), to account for lowering the stocking rate in order for the land to recover.
    - The general difference between is the two rates is that stocking rate is what farmers tend to carry on the land leading to degradation and carrying capacity is what the farmers should have in order to maintain sustainable production.
- Expected increase in carrying capacity: is the expected increase in carrying capacity given a certain agricultural management scenario. In my analysis, the only time an increase in carrying capacity applies is in holistic management (HM). This is due to the fact that in HM you increase your carrying capacity by rotational grazing and thus increasing the utility of the land (one of the major biological and financial benefits). The unit applied is a percentage, which show the % difference.
- Stocking Rate Sheep Total: is the total number of sheep per a 23,000 ha farm set in each ecological zone (unit: heads), despite carrying capacity.
- Carrying Capacity Sheep Total: is the total number of sheep that can be maintained while still maintaining sustainable grazing conditions within a 23,000 ha farm (unit: heads).
- Ewe Sheep: a female sheep, especially when full grown (unit: heads).
- Ewe Hoggets: a young female sheep from about 9 to 18 months of age (unit: heads).
- Replacement Ewes: In every ecological zone, we assume that they will keep 20% of females for replacement of the ewes (unit: heads).
- Wethers: a castrated male sheep (unit: heads).

[34] These are Inputs & Outputs from the parameters tab in the model and pertain to the analysis.

[35] We say "modal" farm here to represent that this is the data that occurs the most frequently and thus the mode for each farm scenario pertaining to each ecological zone.

- Wether Hoggets: a young male sheep from about 9 to 18 months of age that is castrated (unit: heads).
- Rams: an adult male sheep that is not castrated (unit: heads).
- Actual Total: Given the number of sheep and the different types, the actual number of sheep that are on each modal farm. Theoretically, the actual total should equal the stocking rate sheep total (might need to make some minor adjustments here).
- Weaning Rate: the rate in which lambs are weaned from their mother's milk to another forage or grain-based diet (unit: %).
- Mortality Rate of Lambs: the measure of the amount of deaths that occur in the lamb population. This is significant to the farmer due to the fact that lambs are at the beginning of their life cycle, and their mortality is also a large financial loss (unit: %).
- Adult Mortality: the measure of the amount of deaths that occur in the adult population. This is significant to the farmer if the adult serves a large financial and biological purpose such as purchase rams or ewes for breeding (unit: %).
- Farm Consumption: the amount of sheep that the farm consumes and is not part of the financial analysis (unit: heads). We assume that the farmer consumes 50 sheep in the PSA and MCH, but 80 in the MCH due to the fact that are frequently more workers in that environment.
- Culling Ewes: an ewe no longer suitable for breeding and is sold as meat (unit: heads).
- Purchase Rams: We assumed purchasing of rams is set at 20% for the traditional grazing plan and set for 25% for basic planning and holistic management. This is due to the fact that we expect them to have a higher turnover because of the genetic improvement program that Ovis XXI provides (unit: $US/head).
- Sales: all sales are simply the sales of all the animals mentioned above. The replacement % of ewes refers to the amount of ewes that must be replaced in order to maintain breeding programs. The purchase rams are the amount rams that are bought in order to maintain production and breeding (unit: $US/head).

Assumptions specific to the ecological zones in order to reflect modal data:

- Central District (MCH):
  - MCH ecological zones, they do not sell lambs in the traditional grazing scenario. This is due to the fact that overgrazing has diminished their forage availability, and on average in these areas they do not have fat lambs to sell.
- Subandean Grasslands (PSA):
  - PSA no lambs are sold in the traditional grazing scenario (same reasoning for MCH).
- Humid Magellan Steppe (EMH):
  - In EMH, they do not sell wethers, because they sell lambs. In this ecological zone it would be an economic disadvantage to sell wethers due to the fact that it is much more efficient to sell lambs. The reasoning for this is the growing rate that you can achieve from gaining the required weight in a

shorter amount of time. In this area the lambs can grow faster and thus they can sell them in one year in comparison to other areas that will have to wait another year. This is a consequence of the air and degraded land in northern Patagonia in comparison to lush EMH.

Incremental Costs and Calculations

For each scenario, there are incremental costs carried within each ecological zone (see Appendix 3-6). In order for the farmers to benefit from premium pricing, they must comply with flock improvement standards in order to qualify for GRASS certification. By adhering to these standards, farmers have the opportunity to increase their rangeland health, while accessing a series of tangential benefits. For example, one advantage is the ability to produce wool tops, which is wool that has already gone through the spinner. In this process, the farmer and industry have more control over the wool and the ability to trace the product, instead of sending the greasy wool to China. Situations like this incentivize the industry to build demand in the GRASS certification program and pay a premium to the farmer for this increased transparency.

In many situations, complying with the standards can lead to an increase in higher prices and access to premium brands. A large incentive of the project is building demand and purpose for sustainable grazing through the cohesion of business and the environment. Essentially, by increasing the quality of the land, the forage availability increases (e.g. perennial grasses) and thus the quality of the wool. There is a correlation between sustainability and investments in land improvement, and the opportunity to build the business case for sustainable grazing. For example, in the EMH modal farm scenario, the basic planning produces more wool income than traditional grazing because of the rate of genetic improvement. Traditionally, farmers are hesitant to choose basic planning as a sustainable grazing application, due to the fact that the methodology suggests reducing the stocking rate by ~20-30% in order for the land to recover from overgrazing. In this EMH modal scenario, the application of Ovis XXI's selective breeding programs yields in creating very fine and soft merino. By improving the merino through sheep classing programs and genetics over time, the increased price associated with the increased quality compensates the decrease in the amount of wool produced. As a result, farmers are making more money with less sheep.[36] Situations like this act as large incentives for flock improvement programs and these incremental benefits are reflected in the models by certain inputs, such as: carrying capacity, rangeland health index, operational result, micron, yield, etc.

However, there are incremental costs in order to switch from a traditional grazing plan to a sustainable grazing strategy.[37] Below is a list of the necessary conversion costs specific to Ovis XXI's program (i.e. switching from traditional grazing to holistic management):[38]

- Wool classing and testing: these are wool services given by Ovis XXI to help class and bred the sheep for the wool to test for optimal quality.
    - Wool classing costs are US $140 for each shearing day and the amount of shearing days will depend on the amount of animals.
    - We will assume that they will shear 1000 sheep per a day and we will round to the half-day.
    - We will also assume that these costs are incurred once a year.
    - In this analysis, our annual wool classing costs are a factor of multiplying the total number of shearing days needed per annum by the fixed cost of US $140.
- Grassland Evaluation and Monitoring: the incremental cost for conducting grassland evaluation and monitoring in order to ensure a sustainable grazing program (unit: $US).
    - For holistic management, grassland evaluations occur every year and this is reflected in the models as an annual cost.

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[36] GRASS 2.0, 2012.

[37] For all incremental costs and currency conversions in the model, we will assume a 6.7 peso to the dollar exchange rate.

[38] Note: In all of the financial decision models there are not incremental costs to traditional grazing plans. This is due to the fact that within the modal farm scenario, traditional grazing is seen as making no improvements to the land. Therefore, incurring no incremental costs.

    - For basic planning, grassland evaluations occur every two years and this is reflected as a bi-annual cost. In addition, since the model is set as a five-year investment period, we will assume that there are two grassland evaluations that occur in each basic planning scenario.
- Sheep Classing: these are breeding services given by Ovis XXI to help breed the individual animals for optimal production (unit: $US).
    - Sheep classing costs approximately US $134 per a day and in the model are fixed at this rate.
    - Sheep Classing= Fixed Sheep Classing Rate*number of days
    - In the models, we will assume a flat rate of $400 (~$134*3 days). In addition, we will assume transportation costs and taxes this will equal a fixed approximation of US $500.
- GRASS Certification: the incremental cost for incurring the GRASS certification that allows for the traceability program from industry to the farm (unit: $US).
    - We assumed the grass certification to be at a fixed rate of US$.25/head.
    - For grassland certification, the frequency in which you monitor the land is dependent on participation and recovery during your land audits. On average, farms are audited every 2-3 years and we assumed that a fixed cost of grassland certification was incurring once over a five-year span.
- Wool Branding Costs: the additional costs for the branding purposes of including the traceability program (unit: % of wool sale).
    - The wool branding is assumed to be 1% of the price of the sale.
    - The total annual costs for wool branding is 1% of the gross income of wool.
- Holistic Management Education: the incremental costs for attending the mandatory holistic management education, that must be completed in order qualify for the GRASS certification (unit: $US).
    - The cost for holistic management education depends on the amount of days attended. On average most farms participate in five days per year.
    - Therefore, we will assume $US 1000/day is the fixed daily cost, which equals a total cost is US$5000.
    - This incremental cost only applies to holistic management and not basic planning or traditional grazing.

Environmental Health Inputs

In this section, I will give greater detail on the methodology behind calculating the environmental health inputs and grassland evaluation process. In order to monitor the degradation of the land, Ovis XXI must conduct a field audit to create the baseline information. This information is set on a magnitude of factors that equate to the overall rangeland health. From that baseline data, they are able to work with the farmer to create adaptive management plans and continuously improve their agricultural situation per annum. Through a continuous improvement plan, the farmer has flexibility to adjust the necessary constraints to increase their rangeland health index and reverse the environmental degradation of the land.

Assumptions

In order to normalize the environmental inputs, a weighted average is garnered from a series of biological indicators is collected during a field audit conducted by Ovis XXI.[39] Once the baseline data is assessed, the auditor will assign a code for the farm and position a station using GPS to track and monitor the annual progress. This process allows for a continuous improvement plan and the hopeful regeneration of the land resulting in increased productivity to the farmer.

In order to streamline the data of a probable scenario in each ecological zone, the following assumptions were made:

- Rangeland Health Index (RHI): On a numerical range of -100 to +100, that takes into consideration of a series of biological indicators such as: soil erosion, plant litter abundance, biodiversity, etc. These biological indicators are assessed in the grassland evaluation and therefore the direct improvement through implementing sustainable grazing programs for each farm can be monitored and also normalized.
    - In order to account for RHI, it will be averaged within each ecological area (show a table of this modal data).

[39] This methodology is described more in the, "Rangeland Health" section.

Rangeland Health Index

Given the vast expanse of the Patagonian Grasslands, there are many biomes that support this unique ecosystem. Therefore, in an attempt to normalize the key biological indicators that define the land, Ovis XXI has created a list of key qualitative characteristics to be applied when monitoring simplified transects. A scorecard is used to evaluate the biological indicators for the rangeland health index (see Table 9).[40] The Bureau of Land Management proposes this rangeland methodology be applied for the GRASS certification. This practice has been modified to adjust for the pertinent indicators for each adaptive management plan.[41] In addition, Ovis XXI applies the Santa Cruz Method during their grassland evaluations and while conducting their data analysis.[42] Overall, by creating a normalized, numerical index for the rangeland health, Ovis XXI has a repeatable system in order to track the improvement of the land in relation to the application of sustainable grazing programs.

Table 9:

ECOLOGICAL PROCESS			
SOIL STABILITY	WATER CYCLE	NUTRIENT CYCLE	COMMUNITY DYNAMICS
Litter Cover	Litter Cover	Litter cover	Tussock
Vegetation Cover	Vegetation Cover	Litter incorporation	Key species
Soil surface resistance	Soil surface resistance	Biological crust	Decreasers
Wind erosion	Wind erosion	Dung Decomposition	Shrubs
Water erosion	Water erosion	Living organisms	Invasive species
Biological crust			Production

Source: GRASS 2.0, 2012

40 In appendix two, the forms used during the field audits to conduct the rangeland health are listed.
41 Pellant et al., 2005.
42 Borrelli et al., 2001.

Data and Calculations

Once the evaluations are completed, the auditor will calculate the final scores in order to assess the final farm ranking and class. According to the GRASS 2.0 Protocol, the final score is a weighted average of the biological indicators. [43] In order to calculate that weighted average, Ovis XXI uses the methodology of Landscape Functionality Indices (LFI). [44] LFI is as follows:

LFI=1-((Max Score – Observed Score)/(Max Score – Lesser Score))

Each rangeland health index is evaluated on a range from -100 to +100. The final score is a summation of each biological indicator category in order to derive one final score that ranks the overall rangeland health for the farm (see Table 10).

Table 10:

Site Stability Index SSI	Water Cycle Index WCI	Nutrient Cycle Index NCI	Community dynamics CDI
Litter	Litter	Litter	Tussock
Vegetation Cover	Vegetation Cover	Biological Crust	Decreaser Species
Soil Surface Resistance	Soil Surface Resistance	Litter incorporation	Key Forage Species
Wind Erosion	Wind Erosion	Dung Decomposition	Shrubs
Water Erosion	Water Erosion	Living Organisms	Invasive species
Biological Crust			Biomass production

Table13: Landscape Functionality indices

Source: GRASS 2.0, 2012

After the rangeland health index is calculated, there is a series of validation procedures that allow for continuous evaluation. This data is monitored and supported by

[43] GRASS 2.0, 2012

[44] Tonway et al., 2004

the research parties through an online GIS database and used to safely store the information, benchmark the different applied management, and facilitate future adaptations. Through constant assessment, the GRASS certification aims to have a methodological standard that can improve the rangeland health of Patagonia and can be repeated to other global regions that need grassland

Macro-Economic Assumptions

In this section, the macro-economic assumptions in my model are described to conduct the steady-state income analysis over a five-year investment period.

Inflation

In order to calculate the inflation, my models assume that inflation occurs in the same linear regression rate as the devaluation of currency. Given the volatile nature of Argentina's inflation rates, this one-to-one ratio allows these models to maintain the same exchange rate as when data was conducted and assume the same final outputs relative gains or losses. Therefore, relative prices will remain the same due to these assumptions in the model, regardless of inflation rate.

For this analysis in particular, we used the official exchange rate fixed at 6.7 pesos to the U.S. dollar, since this was the exchange rate during my field research in Argentina.[45] In addition, we could not use historical data in order to average an exchange rate over a time series due to the historical instability spanning over a century. Therefore, using historical inflation rate data would provide no correlated analytical interpretations. In order to

[45] Field research was conducted during Dec. 27-Feb. 4, 2011.

mitigate additional risk and hyperinflation from the Argentine peso, we also converted all currency transactions to the US dollar in all of our model calculations.

In addition, these unstable inflation rates have posed to be a major macroeconomic issue for the farmers. Due to the devaluation in currency, the cost in dollars has been decreasing. As a result, the peso rate has become inflated and these massive fluctuations have in turn caused major economic hardships across the region of Patagonia. The Founder of Ovis XXI, Pablo Borrelli, assumes that this situation has greatly affected approximately 95% of farmers throughout the region. With the only unaffected party being the very large farms, which make up less than 5% of the region and have enough expendable cash to not be as greatly effected by the volatility in the market.

In order to conduct sensitivity analysis and calculate inflation for an adjusted interest rate, the following equation is used:

r (inflation rate used) = ((1+r observed)/(1 + inflation)) – 1

The U.S. Annual percentage for inflation in 2011 is 2%, and I accounted for the GDP Price Deflator by applying this percentage. [46] This inflation rate was used to understand the opportunity cost to the farmer and the potential "loss" of the switching costs incurred from shifting to a sustainable grazing program.

Taxes

The total revenue to the farm is charged one percent and the accounting average for a medium farm is approximately US $522.00 per a month.[47] The property tax is 20% of the total value of the land. The records for property tax are quite below the real value, since the

[46] Collins, 1998.
[47] The modal farm in this analysis is 23,000 hectares and thus a medium-sized farm.

farmers do not make property statements every year. In the models, the property tax is calculated by:

Property Tax=20% total land value*1.5% tax rate

In the below table, we can see the following methodology used to calculate the taxes for each land management plan for each ecological zone. For this table in particular, the Central District (MCH) for the traditional grazing plan is illustrated:

Table 11:

EBITDA	-$15,047.19
Entry	$US
Net Income	-$ 15,047.19
Tax Allowance	$ 1,343.28
Dependents	$ 5,000.00
Deduction art. 23	$ 1,343.28
Amount subject to tax	-$ 22,733.76
Fixed Amount	$ 1,641.79
Over 27%	-$ 10,188.12
Tax	-$ 8,546.32

In order to create cohesive analysis across the models, the following tax assumptions were applied:

- Social security is assumed to be a fixed cost of US $150/month.
- Gross income tax is 1% of total income.
- Bank charges are 1% of total revenue.
- Article 23 refers to the Conditions of Deductions for non-taxable profits and family allowances. Under this article individuals are permitted to deduct from their net profits. Taxes for each modal farm are contingent to the net income and the frequency of tax data.

Pricing, Sales, & Purchasing

In regards to pricing livestock, Ovis XXI is attends farm auctions and sets the prices for purchased rams according to the market. They set a floor price of US $140 dollars and then the average in open sales would be US $150 dollars. However, the pricing is slightly higher in the EMH ecological zone, due to the better economy and more established wool industry. Ovis XXI's branding and services are also better known in the southern end of Patagonia. For example, services such as the genetics and breeding programs that greatly enhance the quality of the wool, disease resilience of the livestock, and the overall weight of the rams. In particular, the weight of the ram is a direct implication of the purchase price the farmer can receive, since the prices are based on animal weight. Historically, many regions of Patagonia have overfed the rams to make them exorbitantly obese in order to charge a higher price. Ovis XXI genetics and breeding programs increase the overall size, muscle mass, and inherently the weight, by applying a selective breeding program to create a more resilient animal. In general, the farmers in the EMH region are more informed on these services and the economic opportunity for increased profit from the rams at auction.

In addition, a combination of the regeneration of the land (e.g. increased forage availability) and the breeding programs result in an overall increase in the quality of the wool. A sheep's diet and genetics are shown to be implications for the associated micron. In addition, the breeding programs have also allowed for the farmers to dictate whether the sheep will be used for wool or meat, dependent on the market prices. Historically in the region of Patagonia, farmers had sheep for wool and sheep for meat. This additional flexibility allows them to hedge volatility in the wool pricing market, since. In this analysis, we assumed the current meat prices due to the fact that they more constant and we can rely on current prices of meat as a prediction of our future five-year forecast.[48] Table 12 below shows the difference in prices ranging on the type of meat being sold (e.g. lambs vs. mutton) for the traditional grazing plan in the MCH. These differences are exhibited in the "income" tab of the models, and the unit is $US/kg.

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[48] The price of meat is shown in the table 8 and varies from the differences in animal population. Prices are derived from the US market price on January 20th, 2014.

Table 12:

WOOL	HEADS	KGS/CAB	TOTAL KGS	$US/KG	TOTAL $US
TOTAL INCOME OF WOOL	4,232	4.00	16,928	4.14	**70,082**
MEAT					
	HEADS	KGS/HEAD	TOTAL KGS	$US/KG	TOTAL $US
LAMB SALES	0	0	0	4.80	0
WETHER SALES	500	18	9,000	2.70	24,300
RAM SALES	12	25	309	1.50	464
CULL EWE SALES	276	18	4,968	2.70	13,414
TOTAL INCOME OF MEAT	788		**14,277**		38,177

In order to create cohesive analysis across the data sets, the following assumptions about pricing were made:

Prices & Sales:

- Estimated Wool Price: the estimated wool price for that fifth year that the farmer must pay to the spinner. This price is based on water conditions (a lot of pricing can be based on availability of water due to the amount of forage available for the sheep), production availability, demand from accounts, etc. (unit: $US per a kg of clean wool).
- Lamb Price: the actual price of the lamb at market (here it is set in the fifth year), (unit: $US per kg).
- Lamb Carcass Weight: the actual price is both a combination of the price per a kg multiplied by the total kg (unit: total kg).
  - In assuming carcass weight, we assumed no carcass weight for traditional because they don't sell lambs.
  - For basic planning, we assume 11 kg for lamb weight (unit: total kg).
  - For holistic management, we assume 10 kg for lamb weight in the MCH and PSA zones (unit: total kg).
  - The basic rationale behind this assumption is if you move the sheep more often, then they lose some weight. For EMH, the traditional plan sells lambs, and their weight remains the same since there are no enhancements to the land. In general, the differences in weight are clearer on young animals and this effect will not take place on adult animals.[49]

[49] This rationale is based on Ovis XXI Central Node database that garners the averages of grassland evaluations throughout the ecological regions of Patagonia.

    - The other prices reflect the same concept to the animal husbandry described earlier.
- Sustainable pricing: In Ovis XXI's experience, sustainable pricing is only better given certain pricing.[50] Therefore, the models assume the exchange rate stays as is, in order to account for the economic situation during the time of research. In addition, the assumptions in regards to inflation aim to mitigate results largely affected by hyperinflation.
- Change in Wool Price:
    - Change in the price of wool=%of wool sold with brand (increase of 30%)*change in price of exported wool (20%).
    - Therefore, the change in price for premium branding is 6% (which helps make up the gap between the Australian and Argentine market despite the small quantity). In the model, traditional farms have no access to premium branding and pricing advantage.
- Cull rams: We assumed cull ram prices and weights are the same across each ecological zone. There are very few so the differential is insignificant (unit: $US per a kg).
- Hoggets: In these scenarios, hoggets are set US $0 and weight. This is due to the fact, that this does not fit the most frequent Patagonian modal farm, and very few farms sell hoggets. Therefore, selling hoggets is an anomaly and therefore, we decided to not include these sales in our model.
- Ewe Price: In general, ewe prices remain the same since they are not considered as valuable in the wool and meat market.
- Total Gross Income: The criterion for revenue is that each modal farm generates the proportions of 70% wool and 30% meat. When this assumption is applied, more meat produced results in the relative cost of wool becoming less.

Purchases:

- Simply the prices of all the rams and ewes that must be replaced within a five-year period (unit: $US). Maintaining sheep populations is a large financial cost for the farmer (especially the rams).
- We assumed the price of purchased rams to be the same for each ecological zone.
- Ovis XXI is the leader in flock improvement. Therefore, the pricing is set for each zone by Ovis XXI throughout Patagonia. The same pricing idea is set for basic planning and HM, however they set basic planning and HM prices slightly above traditional grazing plans.

Wool Indicators

One of the main leading wool indicators is the measurement of the micron and considered the most important wool indicator when determining price and quality.

[50] For more information on sustainable pricing methodology, see section, "Specialized Pricing Structure for Patagonia, Inc.".

Inherently, the micron is a guide of quality used to measure the fiber diameter of the wool. Through the flock improvement and land regeneration programs described throughout this analysis, our models reflect this agricultural enhancement as an implication to the increase of quality in the wool. In general, the most common measurement for the wool fiber is 20 microns. On average, the wool industry bases the micron values on a scale, with the smaller numbers being associated to finer wool and thus, a higher price point. In our model this unit is fixed to account for merino wool in the traditional grazing plan, however showing an increase in quality from the microns applied to basic planning and holistic management.[51]

Another important wool indicator is yield and this is a product of many factors such as productivity, forage availability, and climatic events. In Ovis XXI's experience, the pricing for yield is largely dependent on volume; but the total profit is also largely influenced by the weight of greasy wool. Sheep create natural grease called lanolin that helps protect their coat and this additional weight is seen as an indicator on the quality and pricing of wool. However, once the raw wool enters the manufacturing chain, the process to remove lanolin is time intensive and costly.[52] Therefore, the cleaner the wool, the higher the price margin the farmer can receive for the wool. In addition, the weight of greasy wool is affected by the amount of ground cover in each ecological zone. The arid regions have less clean wool per a kg, because there is more dirt in the dry areas and thus more grease. In the wet areas there is less dirt and more ground cover, therefore there is less grease per a wool kg and cleaner wool.

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[51] For example, EMH has 26 Microns because they breed Corriedales (dual purpose breed for both wool and meat). Therefore the micron is 28 at best in the traditional grazing plan and then goes down to 23 for applying basic planning and holistic management.

[52] Lanolin has many industrial applications as well and can be used for cosmetics, lubricants, etc.

Another assumption in the models is that the lambing rate increases when the selective breeding programs are applied. Therefore, lambing rates are adjusted for basic planning and holistic management, due to Ovis XXI's breeding programs since traditional grazing applies no enhancements to the land or animal population. This increase in the genetic improvement, improves the overall quality and inherently the yield. Therefore, the increase of lambing rate is indicative of the increase in the overall animal population. Given that this expansion is over a five-year period, this growth is seen in the lambing season in these models as opposed to older sheep.

The combination of micron, yield, and the weight of greasy wool greatly influence the overall price that the farmer can receive from a harvest. These changes in the wool raw extraction phase across each ecological zone and land management plan are supported by data from field audits and extensive literary reviews. In order to create a cohesive data set across the financial decision models, the following assumptions were applied:

- <u>Micron:</u> one millionth of a meter used to measure the fiber diameter of wool. Generally, lower microns (25 and lower) are used for garments and anything higher than 25 microns is used for more sturdy uses such as rugs, upholstery, etc. (unit: diameter of the fiber).
- <u>Weight of greasy wool per a sheep:</u> wool taken directly from a recently sheared sheep and has not been washed or cleaned. In the wool industry there is a difference between the wool sold that is clean and that is greasy (unit: kg).
  - <u>The price in terms of $US per a kg of greasy wool:</u>
    - Greasy wool=Australian clean wool price*(1-GAP %)*Yield
    - One of the main goals of the project is to bridge the gap between the Australian prices to the Argentine market (with the above price that each farmer gets for greasy wool).[53]
  - <u>Pricing in basic planning and holistic management:</u>
    - The change in wool price=% of wool sold with branding*the change in the price of exported wool

[53] For more information on the topic, see the section, "Wool Pricing Statistics".

- <u>Yield:</u> the natural fiber produced by the skin of domesticated sheep, characterized by its quality of felting together by virtue of its imbricated surface (unit: %).
- <u>Premium Price for Ovis XXI Services/Branding:</u> The premium pricing that farmers have access to if they are involved in Ovis XXI services and branding. In the models only the sustainable grazing plans have access, since the premium prices is set by the brands that have traceability programs and can charge a higher price for their product—and thus give more to the farmer (unit: %).

Labor, Fixed, and Variable Costs

In this section, I will be describing the associated labor, fixed, and variable costs that influence the each land management plan. Starting with labor, there is a combination of temporary labor and permanent positions that help assist the farms. Many temporary personnel are hired in order to support shearing season, since this is the most labor intensive process in the wool industry. For temporary labor these jobs can include duties such as flea dips, lamb marking, and wooly face clipping, which is considered more difficult and a specialization. For temporary labor the rates in our models were conducted by the daily wage multiplied by the most frequent amount of days according to the data in each ecological zone.

Full-time labor had some variation in the number of workers as well, due to the fact that some regions have better economic situations and better wages. In addition, the amount of personnel that can be staffed per a region is also largely dependent on the farm's expendable income. Our models took these types of scenarios when scoping our labor costs. We also adjusted the wages to be reflective of the U.S. currency, in order to mitigate skews in the output results from hyperinflation.

Fixed costs were a product of capital and the necessary components needed to manage a farm, such as trucks, fencing, and social security taxes. Those costs are accumulated annually and are a component on the final output. Variable costs are items that fluctuate year to year, and these costs are items such as purchased rams, transportation, and fodder. All of the data used in these models takes the most frequent scenario for the modal farm and complies an average for each scenario.

In this analysis, I used the following assumptions to calculate the labor, variable, and fixed costs:

<u>Labor Costs:</u>

- <u>Full-time Labor Costs:</u> We assume annual salary for the workers includes monthly pay on a 13-month calendar, contributions, and supplies .
  - Cost per a unit, to signify the cost of a single employee (unit: # of days, $US, staff #)
  - We assumed 1 shepherd for 2000 sheep for traditional grazing, basic planning, and holistic management.
- <u>Temporary Labor:</u> We will assume a per a day fee for the temporary worker that is the most common in the area and the amount of days. For example in the Central District, five people for two to three times a year (shearing, marking, and breeding) and each job will typically last seven days. This is due to the fact that the duration of the stay for temporary workers depends on the amount of sheep and the price will be dependent on the economic vitality of the area. However the amount paid in each ecological zone will be $250 pesos a day, which equates US $37.31 (unit: US $).
- We assumed the following logic for:
  - Temp Staff days= every 2000 sheep being 15 days of work. The equation is =(Total sheep/2000)*15 days

<u>Variable Costs:</u>

- <u>Shearing:</u> The amount of shearing days is variable given it is the amount of heads multiplied by the fixed shearing market price (US$1.90). The amount of days is applied given the frequency data for each modal farm (unit: # of days, $ US).
- <u>Sheep Health:</u> We assume that sheep health is set at a constant of US$0.9 per a sheep. The characteristics for sheep's health are the same and one of the low inputs is that they don't use chemicals for treatment. Therefore, the only treatments that the sheep will have are one vaccine and one flea dip for external parasites. The unit is measured in US$0.9/sheep (this includes a dip for parasites and vaccines) and is seen as variable costs because it is multiplied by the total amount of sheep per a farm (unit: $US).

<u>Fixed Costs:</u>

- <u>Fodder:</u> the cost of the grain-based diet for the sheep (unit: $US).
- <u>Shearing Market Price:</u> is currently US $1.9. Therefore we will use this fixed rate throughout our models (unit: US $).

- Veterinary Rate: is fixed at US $500 a year, farmers don't depend on the vet and generally they will see the farm most commonly two days a year and therefore, vet fees stay the same for every ecological scenario (unit: US $).
- Fodder: For MCH, US $1200 for fodder and hay because there aren't many horses and this cost will increase in PSA (US$2000) and grow larger in the EMH (US$2400), (unit: US $).
- Transportation costs: the associated costs for transporting the wool to the spinner to be placed in the production cycle (unit: $US).
    - We assumed fixed freight costs for all ecological scenarios: the average cost of the freight is US $1 per km, and the average distance is 200 km. One trip is US $200 and on average each farm has four trips per year to service for each season to the spinner. Therefore, this equates to a total of US $800.
    - Each truck will be assumed to be run to be 70,000 km/year, the average cost for a km is US$.27/km.[54]
- Ear Tags: We set the unit cost for an ear tag at US $0.37 and this varies per the amount of sheep on the land. Therefore, we multiplied the ear tag unit cost by the actual total for each ecological scenario (unit: US $).
- Government Tracing Fee: In transporting the wool and meat, the overall government-tracing fee is a very small amount. However, it varies with the amount that you sell. On average, the tracing fee is US $30 per truck and in our models we set it at this fixed amount (unit: US $).
- Maintenance of Assets: This is related to the total value and is in relation to the maintenance of buildings and water. We assume a fixed rate of .5% of total value (unit: US $).
- Energy: (e.g. wood, fuel energy, possibly coal in the south): We will assume $US 448.00/month, since this is the average utility bill of medium farm. Which we will round to an average of US $5000/year and we will assume a fixed value for each modal farm (unit: US $).
- Fencing: On average, all fencing across land management plans is the same and therefore, we assumed the same costs. For example, although there is an increased cost for fencing in holistic management for some plans, some adaptive management plans use no fences at all. Therefore, on average the fencing costs net to being the same across management plans.
    - If we have 23,000 ha, we assume 65,000 perimeter for fencing, 40,000 for internal fencing, and 1,500 yards. We will assume this is the same for each zone.
- Water: (ONLY for HM), there is generally an increase in water use due to the application of rotational grazing patterns and smaller paddocks. On average the increase is: Central is US $20,000; PSA US $10,000; EMH is US $0. There is no

[54] Levinson, D., Corbett, M., & Hashami, M. (2012). Operating costs for trucks. *University of, Twin Cities*, 1-26.

increase in the EMH, since it is humid and rains continuously in that region and therefore additional water is not necessary.[55]

- Supplies: These are items that are given to the workers on the farm, from the farmer (unit: US $).

Capital

One the major output factors for dictating the utility of the investment is the market value of the land. Historically, the market value of the land in Patagonia is very traditional and is a measurement of the amount of sheep the land can withhold in order to maximize productivity. In this analysis, to calculate the market value of the land, the following equation is used:[56]

Market Value= Carrying Capacity * US $300

We use US $300 due to the fact that this is the price that Ovis XXI has experienced most frequently in real transactions. In addition, it is a rounded figure that comes from dividing the market price for known operations and then dividing that number by the total carrying capacity (i.e. total amount of sheep that the land can withhold).

In addition, to create cohesive data the other following assumptions were made through the models given the frequency data for each ecological zone:[57]

- Market Value: the market value of the land in year 5 (unit: $ US).[58]
- Value of Assets: the total value of the assets in year 5 (unit: $ US).
    - Value of Assets is calculated by:
        - Value of Assets= Cash + Total Capital Expenditures + Total Machine Value

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[55] The water is broken into smaller containers and not all of the farmers move their water containers to each paddox. Therefore, we can assume on average that these increases cancel out given the application that happens on the ground to decrease costs. In theory, there would be a large water cost, however in practice the farmers find innovative ways to manage their water resources to decrease total cost (note: in accordance to Ovis XXI experience).

[56] Each market value equation is adjusted to be pertinent to the data applied in each ecological zone.

[57] Other information used to equate costs are from farmer catalogs (Mercado Libre: Listado.mercadolibre.com).

[58] Calculation shown above for market value.

        - Total Capital Expenditures is a product of the total value of the animal population per a modal farm.
        - Machine Value is a product of the machines valued on a five-year depreciation value.
- Land Value: the value of the land in year 5 (unit: $ US).
    - Land value is calculated by:
        - Land Value=Market Value – Non-land Value Assets – Cash
        - Non-land Value Assets are depreciated using the straight-line depreciation model.
- Cash: For our models, we assume cash is 15% of the total revenue.
- Buildings/Capital Infrastructure: We will assume the farmers only have two buildings across each modal farm and 10 windmills for each zone.
- Pick-up Truck: the number of pick-up trucks needed for each ecological plan (same applies for ATV and motorcycles), unit: # of pick-up trucks.
    - For MCH & PSA only 1 truck. With EMH, we will have 2 trucks.
    - For the pick-up truck, the most common in the area is Toyota Hilux. For our model we will assume a new truck. The cost is US $41,194 (assume new).
- Motorcycle: The most common is the Honda Enduro (250 Tornado). The cost is US $6,268 (assume new).
    - For MCH & PSA only 1 motorcycle. With EMH, we will have 2 motorcycles.
- ATV: the most common model is the Panther Parrillero Full. The cost is US $4328 (assume new).
- The only difference with automotive equipment for each zone will be that in EMH you will have two pick-ups. Also in the EMH and PSA, you will also have 2 motorcycles.

Depreciation

I use the straight-line deprecation rate over a five-year investment period. In addition, the deprecation rate is used to amortize the salvage value and calculate the operational result (EBITDA).

In order to create cohesive data throughout the models, the following assumptions were also applied to the depreciation rate:

- Animal Stock: For the models, we do not depreciate the animal stock because they are being replaced on average every five years. The animals are replaced by the new hoggets; therefore depreciating the animal stock would be double counting.

- Horses: The exception to this rule is for the horses, because generally sheep farms do not have a breeding program for horses. Therefore, when the horses get old you need to replace them.
    - We assume 12 years for our horses and depreciate them at a rate of 50%. This reduction in value is applied to our value of total assets.
- Deprecation Rate: Besides the above rules, the models use straight-line depreciation to evaluate capital.

Chapter 5. Analysis:

In this analysis, I calculated the steady-state income analysis for each ecological zone representing each land management scenario. Throughout this research, my steady state income analysis aims to create an equilibrium between production growth and population growth. In addition, this analysis targets the efficient use of resources, but also takes into account the redistribution of the benefits created from the enhancement of the sustainable grazing programs. In order to appropriately assess these incremental costs and evaluate the uncertainty, the financial decision models evaluate a set of major output factors. From this analysis, one can gain a better understanding of the switching costs in the perspective of the farmer over a five-year investment period.

The differences in these values showed the negative profit or loss in each decision model and the probable outcome given the frequency data. This additional analysis gives insight to the relationships between the input and output factors, which the results give a clearer understanding of the best investment strategy for each ecological zone. Additional sensitivity analysis could be conducted with this data set in order to reveal other key findings that may help mitigate financial risks (e.g. modeling longer investment periods).

Results

For a complete overview of the parameters inputting the results, please see Appendix 3-6. The table below, within the MCH for traditional grazing outlines the major output factors that dictate the economic evaluation for the modal farm. (see Table 13). These major output factors will be described in greater detail in the subsequent sections.

Table 13:

ECONOMIC ANALYSIS	
Income Meat	$ 38,177.28
Income Wool	$ 70,081.92
TOTAL INCOME	**$ 108,259.20**
Variable Cost	$ 19,010.60
GROSS MARGIN	**$ 89,248.60**
Fixed Costs	$ 104,295.80
OPERATIONAL RESULT (EBITDA)	**-$ 15,047.19**
Depreciation	$ 23,052.29
Profit Taxes	-$ 8,546.32
RETURN ON EQUITY	**-$ 29,553.16**
TOTAL EQUITY	$ 749,046.53
PROFIT OR LOSS (%)	**-3.95%**

COST OF THE WOOL KILOGRAM (CLEAN WOOL)	
TOTAL COST (Including depreciation)	**$146,358.69**
WOOL COST (% of total income)	**$94,745.74**
KG CLEAN WOOL	9310
COST PER KG CLEAN	**10.18**

In order to organize the copious amounts of data, each model received a color key. Throughout this analysis, the reader can use this this color key in order to further differentiate between each ecological zone. The key is listed below as a helpful tool (see table 14):

Table 14:

Key:

- Light Orange: Central District (MCH)
- Subandean Grasslands (PSA)
- Humid Magellan Steppe (EMH)

Total Income

Throughout my analysis, I found that the total income was positive across all the ecological scenarios. Total income is defined as the sum of all taxable income. In regards to this analysis, total income was comprised of money received from the sales of meat and wool. In addition, give the frequency data throughout this region we assigned that approximately 30% of the total gross income can from meat, while approximately 70% came from wool.

The gain was significantly more in the EMH in comparison to the MCH and PSA. The reasoning for this is due to the fact that EMH has much better biological and financial conditions (e.g. wet climate, good economic conditions, high wages). Therefore, the MCH and the PSA represent the poor to mid-range scenarios that dominate the majority of the Patagonian grasslands. Specifically, the MCH has the slowest growth between each land management plan and this is due to the poorly degraded land and the recovery time being much longer in this zone. Therefore, payback will be adequately longer and the PSA shows a slightly better version of this given that it covers the north south transect alongside the Andes.

In addition, we can notice here that holistic management is the highest income in all three ecological zones. This shows us that in all modal farm scenarios, holistic management has the highest possible income over the five-year investment period despite the incremental switching costs.

Table 15. MCH Total Income:

	TRADITIONAL	BASIC	HOLISTIC
Total Income	$108,259.20	$154,883.85	$187,799.42

Table 16. PSA Total Income:

	TRADITIONAL	BASIC	HOLISTIC
Total Income	$147,010.92	$206,546.13	$286,292.49

Table 17. EMH Total Income:

	TRADITIONAL	BASIC	HOLISTIC
Total Income	$579,485.41	$681,648.25	$1,056,763.17

Gross Margin

Within this analysis, the gross margin is calculated by subtracting the total variable cost from the total income. The total variable costs are both the summation of the variable costs (e.g. temporary labor, shearing costs) and incremental costs (e.g. the switching costs from traditional grazing to a sustainable grazing program).

The gross margin is not represented as a percentage but rather a total dollar value. Over the five-year investment period, the gross margin is a representation of total income that the farmer receives after all variable and incremental costs are taken into account.

In tables 18-20, the same trends apply as in the above section, "Total Income". Holistic Management is still the largest economic potential across all the ecological zones.

In addition, the earnings from MCH to EMH gradually improve and we can assess the overall earnings are largely dependent on the economic and environmental conditions.

Table 18. MCH Gross Margin:

	TRADITIONAL	BASIC	HOLISTIC
Gross Margin	$89,248.60	$129,437.53	$149,266.17

Table 19. PSA Gross Margin:

	TRADITIONAL	BASIC	HOLISTIC
Gross Margin	$121,420.09	$175,581.20	$236,616.73

Table 20. EMH Gross Margin:

	TRADITIONAL	BASIC	HOLISTIC
Gross Margin	$517,042.77	$619,581.61	$947,661.92

Operational Result (EBITDA)

In this analysis, the operational result (EBITDA) is one of the key output factors to compare across the modal farms in terms of profitability. EBITDA is an acronym that stands for Earnings Before Interest Taxes Depreciation Amortization. Essentially, this acronym stands the net income and is represented by revenue minus expenses (excluding interest, taxes, depreciation, and amortization). EBITDA is useful because it allows you to compare operational results without the effect of financing and accounting decisions. In regards to this research in particular, EBITDA is one of the main drivers in assessing whether or not the farmer will be profitable or not in each ecological scenario with each applied land management plan.

In tables 21-23, the EBITDA for traditional grazing is negative in MCH and PSA. This negative number is representative of an operating loss. Given the degradation of the land, this probable outcome showcases the fact that in order to run a profitable operation, the farmers in this region must switch to a sustainable grazing program (e.g. basic planning or holistic management). The necessity to switch is due to a lack of forage availability in the region and therefore, the productivity of running a farm does not outweigh the costs without enhancing the land over the next five years. In addition, holistic management is best financial option despite the upfront switching costs for all ecological zones.

Table 21. MCH Operational Result (EBITDA):

	TRADITIONAL	BASIC	HOLISTIC
Operational Result (EBITDA)	-$15,047.19	$17,068.22	$38,117.61

Table 22. PSA Operational Result (EBITDA):

	TRADITIONAL	BASIC	HOLISTIC
Operational Result (EBITDA)	-$4,630.20	$47,379.26	$97,980.64

Table 23. EMH Operational Result (EBITDA):

	TRADITIONAL	BASIC	HOLISTIC
Gross Margin	$363,110.65	$460,604.46	$747,794.27

Return on Equity

In this analysis, the return on equity is calculated by subtracting depreciation and taxes from the initial investment. Here the return on equity measures the profitability of the farm given the return on investment. This return of investment also includes the increase of biological indicators such as the increase of carrying capacity for implementing sustainable grazing, improvement of rangeland health, and other inputs that would result in improving overall productivity.

In tables 23-25, there is a much larger return on equity in the holistic management scenarios and proves yet again to be the best fiscal option for the farmer. In EMH, the good economic conditions and high quality land shows that farmers do not essentially need to change their land management plan. However, holistic management has the largest return on equity and would be a beneficial investment strategy if the farmer wanted to maximize profits.

Table 23. MCH Return on Equity:

	TRADITIONAL	BASIC	HOLISTIC
Return on Equity	-$29,553.16	-$6,108.91	$9,257.14

Table 24: PSA Return on Equity:

	TRADITIONAL	BASIC	HOLISTIC
Return on Equity	-$23,557.71	$14,409.20	$51,348.20

Table 25: Return on Equity:

	TRADITIONAL	BASIC	HOLISTIC
Return on Equity	$239,537.89	$310,708.36	$520,356.93

Total Equity

Typically, total equity is the amount that the company is financed in common and preferred shares. [59] Given that we are working with land value and improvement programs, the idea of total equity is slightly different. The shareholder in our case is the landowner's capital and the value of non-land assets. The value of the land is calculated by the value of the land (salvage value * value of land). In this analysis, we assume that the land does not depreciate. We calculate non-land assets by taking the total value of non-land assets (i.e. capital expenditures + cash + ordinary improvements) and adding the salvage

[59] "Investopedia: Shareholder's Equity": http://www.investopedia.com/terms/s/shareholdersequity.asp

value. Next, we took the total non-land asset value and divided it by two, in order to depreciate on a straight-line basis for this category.

In tables 26-28, the total equity for MCH and PSA are relatively similar. This is due the fact that these ecological regions share many of the same biological and financial implications and therefore their lands and assets are comparably valued. However, in the EMH the total equity is much larger and this shows that the land value and value of non-land assets is much higher in this region making it a significantly better economic scenario and starting point of investment. This also noticeable in the differences in values in the EMH between land management plans, showing holistic management to have very high payback in terms of total equity in a relatively short investment period.

Table 26. MCH Total Equity:

	TRADITIONAL	BASIC	HOLISTIC
Total Equity	$749,046.53	$752,543.38	$755,012.05

Table. 27. PSA Total Equity:

	TRADITIONAL	BASIC	HOLISTIC
Total Equity	$758,527.54	$762,992.68	$768,973.65

Table 28. EMH Total Equity:

	TRADITIONAL	BASIC	HOLISTIC
Total Equity	$775,307.69	$826,431.31	$1,635,008.95

Percentage of Profit or Loss

In this analysis, we calculated the percentage of profit or loss by taking the return on equity and dividing it by the total equity. This information provides clearer insight for understanding when the marginal investment is a loss or gain comparison to the total equity. For example, if the farm has been very profitable in the past or has positive land conditions, then this loss will not appear to be as significant.

For MCH, we can analyze that the only profitable margin is by applying holistic management. In this modal farm scenario, there is a clear need for holistic management and any other option is seen as poor investment decision. If the farmer continues with traditional grazing, on average the lack of forage availability will cause the farm to go bankrupt. In addition, over a five-year investment period, basic planning does not provide adequate enough benefits to prove as a financially viable option. Therefore, holistic management is shown to be the only profitable scenario in terms of operating over the next five year and with all the other major outputs throughout this analysis, we can confidently inform farmers that holistic management is the best choice in the MCH.

In terms of the PSA, we can see in this modal farm scenario that traditional grazing is also not a financially viable option. Basic planning will provide some marginal benefit, however there be interest would be holistic management. Lastly, the EMH has such fertile soil and positive land conditions, that either land management plan will continue to be profitable. However, the profit or loss percentage is smaller for holistic management than basic planning. This is due to the fact that the incremental costs for holistic management are higher than basic planning. Given the high value of the land and the additional Ovis XXI service benefits (e.g. breeding programs, wool classing), the percentages are still high with basic planning because you are producing high-priced volumes with less sheep. I predict in the long-run the profit margin would start to increase as the land carrying capacity and productivity continues to grow for holistic management and initial investment is paid off.

To gain that insight, additional sensitivity analysis would need to be conducted that took into account a longer investment period.

Table 29. MCH Profit or Loss (%):

	TRADITIONAL	BASIC	HOLISTIC
Profit or Loss (%)	-2.86%	-0.81%	0.64%

Table 30. PSA Profit or Loss (%):

	TRADITIONAL	BASIC	HOLISTIC
Profit or Loss (%)	-3.11%	1.89%	6.68%

Table 31. EMH Profit or Loss (%):

	TRADITIONAL	BASIC	HOLISTIC
Total Equity	30.90%	37.60%	31.83%

Cost of Wool per a Kilogram

In this analysis, we analyzed the cost of wool per a kg as a metric to see which land management plan and ecological zone had highest wool costs per a kg and therefore negatively affecting profit. The following equations for this analysis were calculated as follows:

- Total Cost= Deprecation + Total Fixed Costs + Total Variable Costs
- Wool Cost= (Income from Wool/ Total Income) * Total Cost
- Kilogram of Clean Wool= Total Kg of wool * Yield (%)
- Cost per Kg of Clean Wool= Wool Cost/Kg of Clean Wool

From this analysis, we can observe that the cost for clean wool is the highest in the MCH in comparison to the other ecological zones and specifically for the traditional grazing plan. This is indicative of the low plant cover resulting in more dirt and thus more grease in the wool. Therefore, we can see that farmers would also benefit from increasing forage availability not only for increased productivity, but also an increase in plant cover that would help increase the kilograms of clean wool per a hectare.

The cost of clean wool becomes progressively lower in the PSA and very low in the EMH. The low cost per a wool kilogram in the EMH is representative of the high plant cover, humid environment, and therefore, the lower production of greasy wool. In order to mimic those conditions, farmers would need to increase their overall plant cover.

Table 32. MCH Cost of Wool per a Kilogram:

COST OF THE WOOL KILOGRAM (CLEAN WOOL)	TRADITIONAL	BASIC	HOLISTIC
TOTAL COST (Including depreciation)	$146,358.69	$160,867.92	$172,734.10
WOOL COST (% of total income)	$94,745.74	$62,346.62	$73,118.59
KG CLEAN WOOL (total kg)	9310	7034	9315
COST PER KG CLEAN ($US)	$10.18	$8.86	$7.85

Table 33. PSA Cost of Wool per a Kilogram:

COST OF THE WOOL KILOGRAM (CLEAN WOOL)	TRADITIONAL	BASIC	HOLISTIC
TOTAL COST (Including depreciation)	$176,302.36	$183,828.11	$212,973.09
WOOL COST (% of total income)	$113,461.44	$71,293.64	$90,189.71
KG CLEAN WOOL (total kg)	13712	10510	15907
COST PER KG CLEAN ($US)	8.27	$6.78	$5.67

Table 34. EMH Cost of Wool per a Kilogram:

COST OF THE WOOL KILOGRAM (CLEAN WOOL)	TRADITIONAL	BASIC	HOLISTIC
TOTAL COST (Including depreciation)	$246,391.22	$251,060.27	$338,985.37
WOOL COST (% of total income)	$66,732.65	$83,953.56	$131,612.53
KG CLEAN WOOL	41755	31234	56221
COST PER KG CLEAN	$1.60	$2.69	$2.34

Chapter 6. Conclusions

Recommendations

Throughout my analysis, it was conclusive that holistic management had the highest payback in all of the ecological scenarios and land management plans. In the arid regions (i.e. MCH & parts of PSA), the payback has the largest potential. In the wet regions (i.e. EMH), traditional grazing could still be applied, however there is a large fiscal opportunity by investing in holistic management. My research has shown that the switching costs are worth the upfront investment and that sustainable grazing will on average and have the largest payback in the long run in all of the modal farm scenarios.

In order to continue to support this program, I would recommend Patagonia, Inc., Ovis XXI, and The Nature Conservancy build industry accounts to foster demand for the project. By increasing demand, these partnerships have the opportunity to also increase the volume produced and therefore have more leverage with pricing contracts, influence over farmer's buy-in, and continuous support through the mutual exchange of sourcing and supplying. In addition, supplementary industry accounts with premium brands will also increase awareness on the project and provide more publicity.

If the increase in sustainable grazing programs could be targeted, I would recommend that Ovis XXI focus on improving the Central District (MSC) due to its return on equity potential and severe environmental degradation. I would also recommend further sensitivity analysis of this project to further understand any types of uncertainty pertaining investments in the perspective of the farmer. Additional sensitivity analysis could include modeling a longer investment period, creating a discounted cash flow, or creating a risk assessment that models a natural disaster (e.g. drought) to gain knowledge on which ecological zone reacts the best to sudden impacts.

Overall, this cohesive and modal data summary is a baseline assessment in which one can gain further knowledge on the probable land scenarios in this region. The intention of this research is to support the farmer regenerate the land, increase productivity, and provide information for decision-making. This economic evaluation can be adapted to the information and sources available by the pertinent working groups and be adjusted to model several different scenarios. Through applying this baseline framework, it intends to serve as a guide to help promote future growth and to bolster the continuous work of this project moving forward.

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Appendices:

Appendix 1: Wool Pricing Statistics:

Appendix 1. Australian Wool Market Prices for clean wool

	Harvest 2005/2014										
Micron	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	Average	Deviation	%CV
19.5	8.76	10.15	6.10	9.04	11.54	13.49	13.15	11.68	10.49	2.48	23.65%
20	8.38	9.46	5.52	8.59	10.48	12.95	12.70	11.55	9.95	2.50	25.08%
20.5	8.18	9.14	5.40	8.48	10.35	12.73	12.65	11.50	9.80	2.51	25.61%
21	7.97	8.83	5.28	8.37	10.23	12.51	12.60	11.45	9.65	2.53	26.18%
22	7.62	8.44	5.18	8.10	9.68	11.54	12.24	11.37	9.27	2.39	25.81%
23	7.36	8.13	5.11	7.91	9.37	10.52	12.03	11.26	8.96	2.28	25.49%
24	6.49	7.61	4.96	7.38	8.43	10.05	10.72	9.52	8.14	1.93	23.65%
25	5.29	6.29	4.39	6.22	7.38	8.80	9.34	7.78	6.94	1.70	24.54%
26	5.08	5.64	4.10	5.50	6.58	7.64	8.38	6.98	6.24	1.42	22.69%
28	3.85	4.02	3.32	4.10	5.08	6.50	6.20	6.07	4.89	1.23	25.24%
GAP			27%	25%	17%	20%	25%	25%	23%	0.04	0.03

Source: awex.com, 2014

Appendix 2: Biological Indicators Evaluation Matrix:

NUM.	ATRIBUTE	PROCESS INDICATOR		MAX				MIN
1	LITTER ABUNDANCE	COVER	Class	5	4	3	2	1
			Description	>50%	25-50%	10-25%	1-10%	<1%
2	VEGETATION COVER	BASAL COVER %	Class	5	4	3	2	1
			Description	40-50%	30-40%	10-20%	5-10%	<5%
3	SOIL SURFACE RESISTANCE	CRUST HARDINESS	Class	4	3	2	1	
			Description	Very Hard	Hard	Weak	Loose	
4	WIND EROSION	BLOWOUT/DEPOSITION	Class	4	3	2	1	
			Description	None	< 10%	10-50 %	> 50%	
		ACTIVE PEDESTALS	Class	4	3	2	1	
			Description	None	<5 cm	5-10 cm	> 10 cm	
5	WATER EROSION	ACTIVE RILL						
		ACTIVE WATER FLOW PATTERNS	Class	4	3	2	1	
			Description	None	< 2 cm	2-10 cm	> 10 cm	
		ACTIVE GULLIES						
6	BIOLOGICAL CRUST	COVER	Class	4	3	2	1	0
			Description	> 10%	5-10%	1-5%	<1%	No hay
7	LITTER INCORPORATION	LITTER/SOIL CONTACT	Class	4	3	2	1	0
			Description	High	Mid/high	Medium	Low	Nil

NUM.	ATRIBUTE	PROCESS INDICATOR		MAX				MIN
8	LIVING ORGANISMS	MICROFAUNA EVIDENCE	Class	2	1	0	0	0
			Description	Abundant	Present	None	None	None
9	DUNG DECOMPOSITION	DUNG DISSAPEARANCE RATE	Class	2	1	0	0	0
			Description	Fast	Fair	Slow	Slow	Slow
10	TUSSOCK		Class	5	4	3	2	1
		Vigorous, with seedstalks, green	Description	> 50%	25-50%	10-25%	<10%	<10%
		Decadent, oxidized, no seedstalks		< 10%	<10%	10-20%	20-50%	>50% decad
11	DECREASERS	Frequency	Class	5	4	3	2	1
			Description	Abundant	Present	Few	Rare	None
12	KEY SPECIES		Class	5	4	3	2	1
		Vigorous, with seedstalks, green	Description	> 50%	25-50%	10-25%	<10%	<10%
		Decadent, oxidized, no seedstalks		< 10%	<10%	10-20%	20-50%	>50% decad
13	SHRUBS		Class	5	4	3	2	1
		Vigorous, with flowers, green sprouts	Description	> 50%	25-50%	10-25%	<10%	<10%
		Decadent, deformed, no flowers		< 10%	<10%	10-20%	20-50%	>50% decad
14	INVASIVE SP		Class	0	0	0	-5	-10
		Abundance of invasive species	Description	None	None	Rare	Present	Abundant
15	PRODUCTION	TOTAL BIOMASS PRODUCTION	Class	5	4	3	2	1
		Related TO SITE POTENTIAL	Description	>80%	60-80%	40-60%	20-40%	<20%

Appendix 3. Parameters in the Central District (MSC):

MODEL: MSC TRAD				
Table 1: Variable Inputs	Unit			
		Central District (MCH & MSC)		
		Traditional	Basic Planning	Holistic Management
I. Population Dynamics				
Total Area	ha	23,000	23,000	23,000
Carrying Capacity	head/ha	0.15	0.15	0.21
Stocking Rate	head/ha	0.20	0.15	0.21
Expected Increase in carrying capacity	%			0.4
Stocking Rate Sheep Total	%	4600	3450	4830
Carrying Capacity Sheep Total	%	3450	3450	4830
Ewe Sheep	heads	2576	2587.5	3622.5
Ewe Hoggets	heads	644	690	966
Wethers	heads	598	50	50
Wether Hoggets	heads	644	60	60
Rams	heads	103.04	77.625	108.675
Actual Total	heads	4565.04	3465.125	4807.175
Weaning rate	%	0.5	0.8	0.7
Mortality Rate of lambs	%	0.1	0.08	0.08
Adult Mortality	%	0.08	0.05	0.05
Farm Consumption	heads	50	50	50
Culling Ewes	LCA%	0.15	0.17	0.17
II. Sales				
Wethers for sale	heads	500.16	0	0
Rams for sale	heads	12	12	16
Lambs for Sale	heads	0	1257.525	1427.265
Hoggets for sale	heads	0	0	0
Replacement percentage of Ewes	heads	515.2	517.5	724.5
Purchase rams	heads	20.608	15.525	21.735
III. Wool Indicators				
Yield	%	0.55	0.58	0.58
Weight of greasy wool weight per sheep	kg	4	3.7	3.5
Micron	diameter of fiber	20.5	19.5	19.5
Premium Price for Ovis XXI Services/Branding	%	0	0.06	0.06
VIII. Incremental Costs				
Wool Classing and Testing	# days	0	3.47	4.81
Grassland Evaluation and Mointoring	$US	0	2500	5000
Sheep Classing	$US	0	500	500
Grass Certification	$US/head	0	0.25	0.25
Wool Branding Costs	% of wool sale	0	0.01	0.01
Holistic Management Education	$US	0	0	5000
IX. Fixed Costs				
Market Value	$US	1035000	1035000	1449000
Value of Assets	$US	751700.12		
Land Value	$US	283300		
Pick-up Truck	# of trucks	1	1	1
ATV	# of ATVs	0	0	0
Motorcycles	# of motorcycles		Motorcycles	# of motorcycles
X. Environmental Indicators				
RHI (range -100 to 100)	index	-30	-20	10

	IV. Prices				
	Estimated Wool Price	$US per a kg of clean wool	4.14	4.95	4.95
	Lamb price	$US per kg	4.8	4.8	4.8
	Lamb Carcas Weight	total kg	0	11	10
	Price of Ewes	$US per kg	2.7	2.7	2.7
	Ewe Carcas Weight	total kg	18	20	20
	Price of wethers	$US per kg	2.7	2.7	2.7
	Wethers Carcas Weight	total kg	18	20	20
	Price of cull rams	$US per kg	1.5	1.5	1.5
	Cull ram Carcas Weight	total kg	25	28	28
	Price of hoggets	$US per kg	0	0	0
	Hoggets Carcas Weight	total kg	0	0	0
	V. Purchases				
	Price of purchased rams	$US/head	120	150	150
	Price ofPurchased Ewes	$US/head	60	60	60
	VI. Labor Costs				
	Manager	staff #	1	1	1
	Manager annual salary per a worker	$US	23334.96	23334.96	23334.96
	Foreman	staff #	0	0	0
	Foreman annual Salary per a worker	$US	0	0	0
	Shepherd Worker/Other Workers	staff #	2	2	2
	Shepherd Worker/Other annual Salary per a worker	$US	28181.05	28181.05	28181.05
	Temporary Employees	staff total days	34.5	25.875	36.225
	Temporary Salary	$US	37.31	37.31	37.31
	VII. Costs				
	Fodder/Hay	$US	1200	1200	1200
	Transportation Costs	$US	800	800	800

Appendix 3. Parameters in the Subandean Grasslands (PSA):

Table 1. Variable Inputs	Unit			
		Subandean Grasslands (PSA)		
		Traditional	Basic Planning	Holistic Management
I. Population Dynamics				
Total Area	ha	23,000	23,000	23,000
Carrying Capacity	head/ha	0.2	0.2	0.32
Stocking Rate	head/ha	0.27	0.2	0.32
Expected Increase in carrying capacity	%			0.6
Stocking Rate Sheep Total	%	6210	4600	7360
Carrying Capacity Sheep Total	%	4600	4600	7360
Ewe Sheep	heads	3477.6	3450	5520
Ewe Hoggets	heads	869.4	920	1472
Wethers	heads	807.3	50	50
Wether Hoggets	heads	869.4	60	60
Rams	heads	139.104	103.5	165.6
Actual Total	heads	6162.804	4583.5	7267.6
Weaning rate	%	0.6	0.8	0.7
Mortality Rate of lambs	%	0.1	0.08	0.08
Adult Mortality	%	0.08	0.05	0.05
Farm Consumption	heads	50	50	50
Culling Ewes	LCA%	0.15	0.17	0.17
II. Sales				
Wethers for sale	heads	692.716	0	0
Rams for sale	heads	16.69248	15.525	24.84
Lambs for Sale	heads	0	1676.7	2174.88
Hoggets for sale	heads	0	0	0
Replacement percentage of Ewes	heads	695.52	690	1104
Purchase rams	heads	27.8208	20.7	33.12
III. Wool Indicators				
Yield	%	0.6	0.65	0.65
Weight of greasy wool weight per sheep	kg	4	3.7	3.5
Micron	diameter of fiber	20.5	19.5	19.5
Premium Price for Ovis XXI Services/Branding	%	0	0.06	0.06
IV. Prices				
Estimated Wool Price	$US per a kg of clean wool	4.14	4.95	4.95
Lamb price	$US per kg	4.8	4.8	4.8
Lamb Carcas Weight	total kg	0	11	10
Price of Ewes	$US per kg	2.7	2.7	2.7
Ewe Carcas Weight	total kg	18	20	20
Price of wethers	$US per kg	2.7	2.7	2.7
Wethers Carcas Weight	total kg	18	20	20
Price of cull rams	$US per kg	1.5	1.5	1.5
Cull ram Carcas Weight	total kg	25	28	28
Price of hoggets	$US per kg	0	0	0
Hoggets Carcas Weight	total kg	0	0	0

V. Purchases				
Price of purchased rams	$US/head	120	150	150
Price ofPurchased Ewes	$US/head	60	60	60
VI. Labor Costs				
Manager	staff #	1	1	1
Manager annual salary per a worker	$US	23334.96	23334.96	23334.96
Foreman	staff #	1	1	1
Foreman annual Salary per a worker	$US	0.00	0.00	0.00
Shepherd Worker/Other Workers	staff #	2	2	2
Shepherd Worker/Other annual Salary per a worker	$US	28181.05	28181.05	28181.05
Temporary Employees	staff total days	46.575	34.5	55.2
Temporary Salary	$US	37.31	37.31	37.31

VII. Costs				
Fodder/Hay	$US	2000	2000	2000
Transportation Costs	$US	800	800	800
VIII. Incremental Costs				
Wool Classing and Testing	# days	0.00	4.58	7.27
Grassland Evaluation and Mointoring	$US	0	2500	5000
Sheep Classing	$US	0	500	500
Grass Certification	$US/head	0.00	0.25	0.25
Wool Branding Costs	% of wool sale	0	0.01	0.01
Holistic Management Education	$US	0	0	5000
IX. Fixed Costs				
Market Value	$US	1380000	1380000	2208000
Value of Assets	$US			
Land Value	$US			
Pick-up Truck	# of trucks	1	1	1
ATV	# of ATVs	1	1	1
Motorcycles	# of motorcycles		Motorcycles	# of motorcycles
X. Environmental Indicators				
RHI (range -100 to 100)	index	-30	-10	15

Appendix 3. Parameters in the Humid Magellan Steppe (EMH):

Table 1. Variable Inputs	Unit			
		Humid Magellan Steppe (EMH)		
		Traditional	Basic Planning	Holistic Management
I. Population Dynamics				
Total Area	ha	23,000	23,000	23,000
Carrying Capacity	head/ha	0.5	0.5	0.9
Stocking Rate	head/ha	0.7	0.5	0.9
Expected Increase in carrying capacity	%			0.9
Stocking Rate Sheep Total	%	16100	11500	20700
Carrying Capacity Sheep Total	%	11500	11500	20700
Ewe Sheep	heads	12075	8625	15525
Ewe Hoggets	heads	3220	2300	4140
Wethers	heads	50	50	50
Wether Hoggets	heads	60	60	60
Rams	heads	362.25	258.75	465.75
Actual Total	heads	15767.25	11293.75	20240.75
Weaning rate	%	0.75	0.9	0.8
Mortality Rate of lambs	%	0.06	0.04	0.04
Adult Mortality	%	0.05	0.03	0.03
Farm Consumption	heads	80	80	80
Culling Ewes	LCA%	0.17	0.2	0.2
II. Sales				
Wethers for sale	heads	0	0	0
Rams for sale	heads	54.3375	43.9875	79.1775
Lambs for Sale	heads	5494.125	5295.75	8041.95
Hoggets for sale	heads	0	0	0
Replacement percentage of Ewes	heads	2415	1725	3105
Purchase rams	heads	72.45	51.75	93.15
III. Wool Indicators				
Yield	%	0.65	0.7	0.7
Weight of greasy wool weight per sheep	kg	4.2	4	4
Micron	diameter of fiber	28	23	23
Premium Price for Ovis XXI Services/Branding	%	0	0.06	0.06

II. Sales				
Wethers for sale	heads	0	0	0
Rams for sale	heads	54.3375	43.9875	79.1775
Lambs for Sale	heads	5494.125	5295.75	8041.95
Hoggets for sale	heads	0	0	0
Replacement percentage of Ewes	heads	2415	1725	3105
Purchase rams	heads	72.45	51.75	93.15
III. Wool Indicators				
Yield	%	0.65	0.7	0.7
Weight of greasy wool weight per sheep	kg	4.2	4	4
Micron	diameter of fiber	28	23	23
Premium Price for Ovis XXI Services/Branding	%	0	0.06	0.06

IV. Prices				
Estimated Wool Price	$US per a kg of clean wool	2.44	5.11	5.11
Lamb price	$US per kg	4.8	4.8	4.8
Lamb Carcas Weight	total kg	11	13	11
Price of Ewes	$US per kg	2.7	2.7	2.7
Ewe Carcas Weight	total kg	20	23	23
Price of wethers	$US per kg	2.7	2.7	2.7
Wethers Carcas Weight	total kg	0	0	0
Price of cull rams	$US per kg	1.5	1.5	1.5
Cull ram Carcas Weight	total kg	25	28	28
Price of hoggets	$US per kg	0	0	0
Hoggets Carcas Weight	total kg	0	0	0
V. Purchases				
Price of purchased rams	$US/head	120	180	180
Price ofPurchased Ewes	$US/head	60	60	60
VI. Labor Costs				
Manager	staff #	1	1	1
Manager annual salary per a worker	$US	23334.96	23334.96	23334.96
Foreman	staff #	1	1	1
Foreman annual Salary per a worker	$US	0.00	0.00	0.00
Shepherd Worker/Other Workers	staff #	2	2	2
Shepherd Worker/Other annual Salary per a worker	$US	28181.05	28181.05	28181.05
Temporary Employees	staff total days	120.75	86.25	155.25
Temporary Salary	$US	37.31	37.31	37.31
VII. Costs				
Fodder/Hay	$US	2400	2400	2400
Transportation Costs	$US	800	800	800
VIII. Incremental Costs				
Wool Classing and Testing	# days	0.00	11.29	20.24
Grassland Evaluation and Mointoring	$US	0	2500	5000
Sheep Classing	$US	0	500	500
Grass Certification	$US/head	0.00	0.25	0.25
Wool Branding Costs	% of wool sale	0	0.01	0.01
Holistic Management Education	$US	0	0	5000
IX. Fixed Costs				
Market Value	$US	3450000	3450000	6210000
Value of Assets	$US			
Land Value	$US			
Pick-up Truck	# of trucks	2	2	2
ATV	# of ATVs	1	1	1
Motorcycles	# of motorcycles		Motorcycles	# of motorcycles
X. Environmental Indicators				
RHI (range -100 to 100)	Index	0	35	55